DRAFT
PROSPECT CREEK WATERSHED SEDIMENT TMDLS
AND FRAMEWORK FOR WATER QUALITY RESTORATION

January 11, 2008

Table of Contents

Table of Tables

Table of Figures

List of Appendices

EXECUTIVE SUMMARY

General Description of Clean Water Act, 303d list and Montana Standards

The federal Clean Water Act requires that states and tribes restore and maintain the chemical, physical, and biological integrity of the nation's waters. The State of Montana has adopted water quality standards necessary for protecting it's identified beneficial uses; namely, fisheries, aquatic life, agriculture, industrial use, drinking water, and recreation. Water quality impacts to these beneficial uses are identified by comparing existing water quality to the state water quality standards. Rivers, streams and lakes that do not meet these standards are identified on an impaired waters list, often referred to as the 303(d) list. This list is published and updated every two years as part of the Department of Environmental Quality's 305(b) integrated report. For waters identified as being impaired by a pollutant on this list, states and tribes must develop a total maximum daily load (TMDL) for each pollutant. The TMDL sets the level by which to achieve water quality standards and protect beneficial uses.

General Description of the Prospect Creek Watershed

This document addresses the streams in the Prospect Creek watershed that are or have been listed on Montana's 303(d) list. Sediment TMDLs have been developed for Prospect Creek, Clear Creek, and Dry Creek. Metal TMDLs were previously developed for Prospect Creek, Cox Gulch, and Antimony Creek and are detailed in Total Maximum Daily Loads for Metals in Prospect Creek Watershed (DEQ, 2006a). The assessment contained within this document describes the physical, biological, and cultural setting; water quality status; pollutant sources; and strategies to attain and maintain water quality standards, including TMDL. Development of all TMDLs and the preparation of this document was conducted by the Montana Department of Environmental Quality in consultation with the Green Mountain Conservation District and the Prospect Creek Watershed Council representing a broad range of stakeholders in the basin.

The Prospect Creek watershed drains 182 square miles (108,160 acres) located on the eastern face of the Bitterroot Mountains in western Montana. Draining northeast from its headwaters near the Montana-Idaho border, mainstem Prospect Creek joins the Clark Fork River at Noxon Reservoir 0.5 miles from the town of Thompson Falls in Sanders County, Montana (**Figure 1-1**). Primary tributaries in the watershed include Dry, Clear, Wilkes, Antimony, and Crow creeks and Cooper and Cox Gulch. Multiple smaller tributaries occur throughout the watershed and generally reflect seasonal intermittency.

The Prospect Creek watershed fish community was originally comprised of nine native species, with bull trout (Salvelinus confluentus) and westslope cutthroat trout (Oncorhynchus clarki lewisi) the representative trout species. The Prospect Creek watershed is considered core habitat for bull trout (MBTRT, 2000) and was proposed by the U.S. Fish and Wildlife Service (2002) as critical bull trout habitat. Bull trout are federally listed as threatened by the U.S. Fish and Wildlife Service, and classified as a sensitive species by the U.S. Forest Service. Westslope cutthroat trout are recognized by the State of Montana as a Species of Special Concern (Roedel, 1999).

In the Prospect Creek watershed, much of the land is owned by the US Forest Service, with private landowners owning only 6% of the overall watershed area. Land use has transitioned over time although timber harvest remains a secondary land use in the headwaters of the watershed. Historic and current mining has also played an active role in the economic development of the area. Valley bottom land uses include irrigated pasture, grazing, and timber harvest. Other land uses include transportation, recreational hunting and fishing, and off-highway vehicle operation. The Prospect Creek watershed also serves as a corridor for pipeline, electric, and road infrastructure.

Key Findings – TMDLs developed, Allocations, and Future Actions

Development throughout the watershed, infrastructure management, physical stream straightening, flood plain encroachment, and resource extraction has combined to impact water quality in the Prospect Creek watershed. Sediment is the major pollutant of concern addressed in this document. Five significant sources have been identified as contributing sediment due to anthropogenic influence; bank erosion, surface erosion from roads, potential culvert failure, timber harvest, and road traction sanding. The sediment TMDL and allocations are based from the analysis of loads from all of these sources, including the natural contribution of sediment from bank erosion and the watershed. TMDLs and allocations for Prospect Creek, Clear Creek, and Dry Creek are shown in the table below. Bank erosion related to anthropogenic influences is the largest contributor of sediment within the watershed.

To achieve the TMDL, this assessment has found that sediment must be reduced by 58% throughout the Prospect Creek watershed, and by 25% within the Clear Creek subwatershed. In order to meet these reductions, restoration efforts will need to establish healthy and mature riparian corridors including in those stream corridors that contain powerline or pipeline routes; improve culverts, road/stream crossings, and forest and county road design including present and future roads; ensure all appropriate best management practices for future timber harvest and streamside activities are followed; as well as engage in active channel restoration and stabilization. The TMDL process and the conclusions based on the assessments from this study incorporate an adaptive management strategy. The values presented here are not static, and it is expected that stakeholders and agency personnel interested in the Prospect Creek watershed will further assess and refine these results and strategies as improvements are made both to water quality in the watershed and the methods to assess it.

Table Ex-1. Water Quality Plan and TMDL Summary Information

Impaired Water Body Summary	According to the State's 2006 303d list: **Prospect Creek –** Alteration in stream-side or littoral vegetation cover; Metals **Clear Creek** - Alteration in stream-side or littoral vegetation cover; Sediment/Siltation **Dry Creek** - Alteration in stream-side or littoral vegetation cover; Chlorophyll a
Impacted Uses	**Prospect Creek** <u>Not Supporting</u>: Cold Water Fishery, Aquatic Life, and Drinking Water **Clear Creek and Dry Creek** <u>Partially Supporting</u>: Cold Water Fishery, Aquatic Life
Identified Pollutant Source Descriptions	• Bank Erosion – anthropogenic influenced bank erosion as a result of riparian clearing, stream channel modification and channelization, increased water yield, bank hardening, and stream crossings • Forest Roads – erosion of sediment from unpaved forest roads, as contributed at road-stream crossings • Culvert Failure – potential sediment load from failure at given flow events • Upland Timber Harvest – sediment as a result hillside destabilization and vegetation removal • Traction Sand – road sand applied and associated delivery to stream along county highways throughout the Prospect Creek watershed
Sediment Targets Indicators	• <15% Percent Surface Fines in Riffles < 6.35 mm (pebble count) • <10% Percent Surface Fines < 6.35 mm in Pool Tails and Riffles (grid toss or equivalent) • <28% Percent Substrate Fines in Pool Tails < 6.35 mm (McNeil cores) • >26 Pool Frequency (number of pools per unit length) for Prospect Creek mainstem B and C stream types • >47 Pool Frequency for Prospect Creek tributary B and C stream types • <30 Width to Depth Ratio (ratio of bankfull width to bankfull depth at riffle cross sections) for Prospect Creek mainstem B and C stream types • <20 Width to Depth Ratio for Prospect Creek tributary B and C stream types • 1.2 – 1.4 Sinuosity

Table Ex-1. Water Quality Plan and TMDL Summary Information

	• 40-70 Riffle Stability Index • Large Woody Debris (amount of large woody debris per unit length); dependent on stream size • Riparian Vegetation (using densiometer) >75% for streams with active channel width < 75 feet; >60% for streams with active channel width > 75 feet • Macroinvertebrate Populations
Other Use Support Objectives (non-pollutant & non-TMDL)	• Fish Passage • Large Woody Debris (as related to habitat alteration impairment)
Sediment TMDL and Allocation Summary	**Prospect Creek TMDL**: 58% reduction in total loading achieved via loading reductions applied to all major anthropogenic sources **Clear Creek TMDL**: 25% reduction in total loading achieved via loading reductions applied to all major anthropogenic sources **Dry Creek TMDL**: 29% reduction in total loading achieved via loading reductions applied to all major anthropogenic sources **Allocations (applied to each 6th code HUC):** • Bank Erosion – 80% reduction • Forest Roads – 50% reduction • Culvert Failure – 77% reduction • Upland Timber Harvest – ensure all BMPs and reasonable land, soil, and water conservation practices are employed for future harvest activities • Traction Sand – 31% reduction
Restoration & Mitigation Strategy	• Improve Riparian Corridor Health and Maturity • Culvert Upgrade for Fish Passage Improvement and Failure Risk Reduction • Restoration and Stabilization of Bank Erosion from Anthropogenic Influences including Private Development, and Road and Utility Corridors • Reduce Sediment Delivery from Forest Roads Through Road BMP Improvements and Decommissioning • Channel Reconstruction Where Appropriate To Return Stream Conditions to Single Channel and More Natural Morphology

SECTION 1.0
INTRODUCTION

1.1 Prospect Creek Watershed Summary

Prospect Creek is a fifth order watershed draining approximately 182 square miles (116,480 acres) located on the eastern face of the Coeur d'Alene Mountains of the Bitterroot Range in western Montana. Draining northeast from its headwaters near the Montana-Idaho border, mainstem Prospect Creek joins the Clark Fork River at Noxon Reservoir 0.5 miles from the town of Thompson Falls in Sanders County (**Figure 2-1**). Other major streams within the Prospect Creek watershed include Dry Creek, Clear Creek, Wilkes Creek, Antimony Creek, Cox Gulch, and Cooper Gulch. Multiple smaller tributaries and gulches occur throughout the basin and generally reflect seasonal intermittency. 94% of the Prospect Creek watershed exists within USFS lands, with the rest under private ownership.

Historic and current silviculture practices, agriculture, powerline and pipeline infrastructure, grazing, and county and USFS forest access roads have all affected Prospect Creek and its primary tributaries. These anthropogenic influences have lead to increased sediment from landscape and in-stream sources, changes in morphology and habitat conditions, and altered riparian age class and composition.

The Prospect Creek watershed is considered core spawning and rearing habitat for bull trout, a federally listed threatened species, and was proposed by the U.S. Fish and Wildlife Service (2002) as critical bull trout habitat. Westslope cutthroat trout are recognized by the State of Montana as a Species of Special Concern (Roedel, 1999) and are also present within the watershed.

1.2 TMDL as Part of a Water Quality Restoration Plan

Development of a TMDL water quality restoration plan follows a series of successive steps, which are described below to provide the reader with a general understanding of the process that was used in developing the Prospect Creek plan.

The first step in developing a water quality restoration plan is to thoroughly evaluate and describe the water quality problems of concern. This includes understanding the characteristics and function of the watershed, documenting the location and extent of the water quality impairments, and identifying each of the contributing causes and sources of impairment. Pollution source assessments are performed at a watershed scale because all potential sources of the water quality problems must be considered when developing the restoration plan.

The next step in the process is to develop water quality targets, or restoration goals, for each impaired stream segment and for each pollutant of concern. These targets will be used as restoration benchmarks and will help to identify what improvements or restoration measures are needed throughout the watershed. The required pollutant reductions and corresponding restoration measures are then allocated across the watershed planning area, the sum of which,

when met equal the Total Maximum Daily Load. This allocation process may be applied on the basis of land use (e.g. forestry, urban, mining, transportation, etc.), land ownership (federal, state, private), sub-watersheds or tributaries, or any combination of these. Specific allocations are also established for future growth and development in the watershed, and for any natural sources of impairment that may be present.

The pollutant allocations and restoration measures become the basis for a water quality restoration strategy, which may include a combination of non-point and point source pollution control measures. Montana has adopted a policy of voluntary compliance for addressing many non-point sources of pollution emanating from private lands. As a result, non-point source control measures rely heavily on public education and other programs that encourage private landowners to apply appropriate best management practices and additional land, soil, and water conservation practices where necessary. Point source pollution is regulated through a state-administered discharge permit program, and any point source allocations that are included in the restoration plan will become a mandatory component of the discharge permits.

Lastly, the water quality restoration plan must include a monitoring component designed to evaluate progress in meeting the water quality targets established by the plan and to ensure that the restoration measures are, in fact, implemented. The monitoring strategy also provides useful information to help fine-tune the restoration plan over the long-term. This process is called adaptive management, and it is a frequent component of watershed-scale restoration plans because of the complexity of the water quality problems, and the inherent uncertainties involved with establishing cause-and-effect relationships between pollution sources and their effects over such large geographic areas.

Taken together, the steps in the water quality restoration planning process described above constitute a water quality-based approach to water pollution control, which is also known as the Total Maximum Daily Load process.

1.3 2006 List Summary and TMDLs Written

Stream	Assessment Unit	2006 Listings	TMDL Completed	Justification
Prospect Creek	MT76N003_020	Alteration in stream-side or littoral vegetation cover	Yes	Current load above target and significant sources exist basin wide; TMDL completed for Sediment
		Metals	Yes	TMDL completed for metals in 2006*
Dry Creek	MT76N003_070	Alteration in stream-side or littoral vegetation cover	Yes	Although not listed for sediment, current loads above target and significant sources exist basin wide; TMDL completed for Sediment
		Chlorophyll a	No	Chlorophyll a not addressed in this documnt
Clear Creek	MT76N003_050	Sediment-Siltation	Yes	TMDL completed
		Alteration in stream-side or littoral vegetation cover	Yes	TMDL for sediment addresses this cause
Antimony Creek	MT76N003_021	Arsenic	Yes	TMDL completed for metals in 2006*
		Lead	Yes	TMDL completed for metals in 2006*
Cox Gulch	MT76N003_022	Lead	Yes	TMDL completed for metals in 2006*
		Zinc	Yes	TMDL completed for metals in 2006*

* See Total Maximum Daily Loads for Metals in Prospect Creek Watershed, October 2006

Within this document, Sediment TMDLs have been developed for Prospect Creek, Clear Creek, and Dry Creek.

Dry Creek is listed on the 2006 303d list as impaired from Chlorophyll a, a pollutant associated with nutrients, but this pollutant is not addressed via TMDL as part of this document.

1.4 Document organization

The main body of this document contains the necessary information to asses and develop the TMDLs and allocations for those pollutants affecting water quality, along with information that provides a contextual description of the processes and characteristics that influence water quality in the Prospect Creek watershed.

The Watershed Characterization (**Section 2**) is a source of general information regarding physical and biological character, constraints, conditions, as well as historical data and anecdotes that help put the Prospect Creek watershed into context with its environment.
Section 3 describes the applicable Water Quality Standards for the State of Montana, and how those standards regulate and define the course of action for developing TMDLs for streams appearing on Montana’s 303(d) Impaired Waters List.

Current water quality and habitat conditions within the Prospect Creek watershed are presented in Section 4, and compared to target conditions that indicate departure from state standards. Based on this comparison, water quality impairment is determined and streams are designated for TMDL development.

Section 5 provides details of all of the significant sources for those pollutants of concern including information for how those sources were identified, analyzed, and ultimately quantified into loads.

Total Maximum Daily Loads and allocations of allowable loads from the various sources are discussed in Section 6. Loading capacity and seasonality is described, as well as the assumptions, uncertainties, and margins of safety that are included in analysis and development of TMDL at the watershed scale.

Suggestions for implementation of actions to meet the goals of the water quality restoration plan and monitoring to refine and assess the findings of this study are presented in the final two sections of this document (**Sections 7 and 8**).

Lastly, additional detail for some of the methods, data, and conclusions within this document is provided in corresponding appendices when warranted.

SECTION 2.0
WATERSHED CHARACTERIZATION

2.1 Watershed and Subbasin Location

Prospect Creek is a fifth order watershed draining approximately 182 square miles (116,480 acres) watershed located on the eastern face of the Coeur d'Alene Mountains of the Bitterroot Range. Draining northeast from its headwaters near the Montana-Idaho border, mainstem Prospect Creek joins the Clark Fork River at Noxon Reservoir 0.5 miles from the town of Thompson Falls in Sanders County, Montana (**Figure 2-1**). The planning area comprises the entire Prospect Creek 5th Hydrologic Unit Code (17010213) in the Lower Clark Fork Watershed in the Columbia Basin.

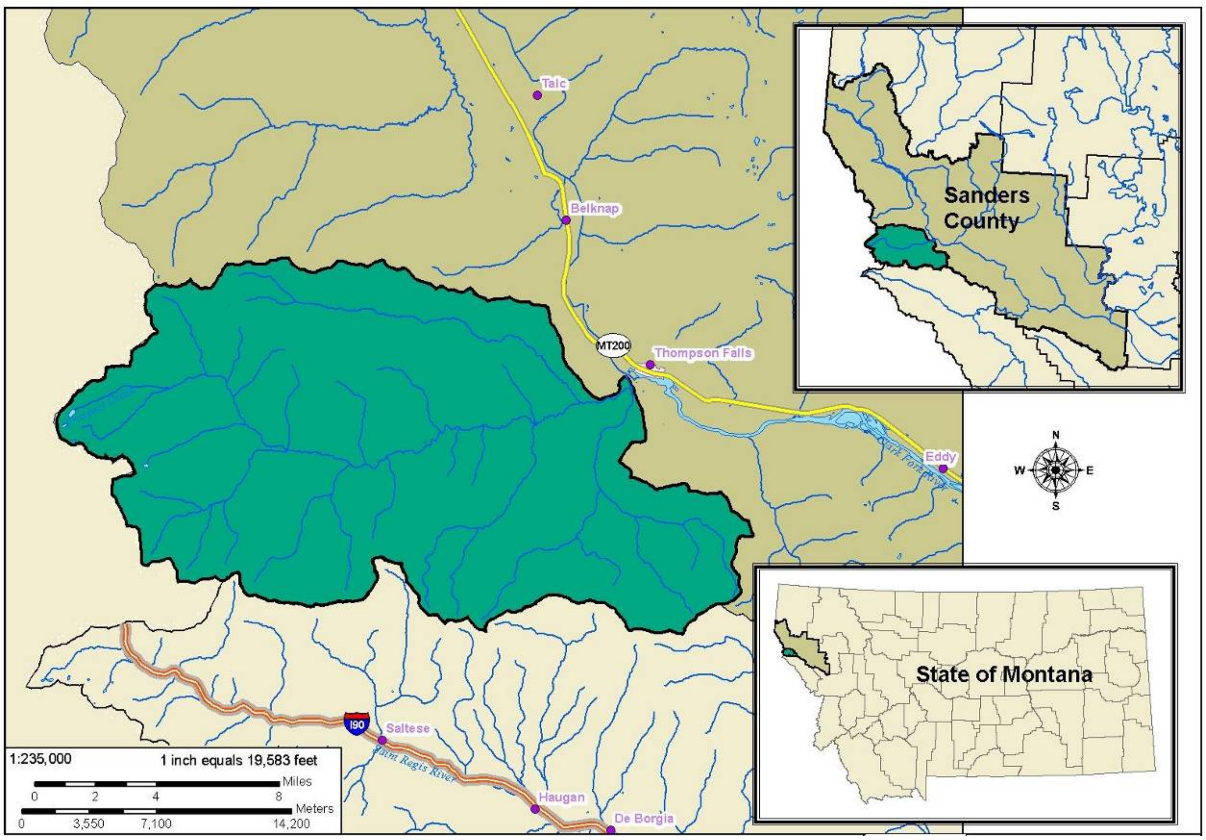


Figure 2-1. Prospect Creek Watershed Location

2.2 Land Ownership

The U.S. Forest Service is the dominant landowner in the Prospect Creek drainage, and private landowners owning a fraction of the overall watershed area **(Table 2-1)**. Private land is primarily located in the valley bottoms adjacent to the stream corridor. Utility and infrastructure corridors exist through easements and special use permits granted to entities such as Yellowstone Pipeline, Bonneville Power Association, Northwestern Energy, and Montana Department of Transportation by the USFS and private landowners.

Table 2-1. USFS Land Ownership Summary for the Prospect Creek Watershed

From USDA,2000		
6th Code HUC	**FS Ownership (mi2)**	**Percent of HUC in FS Ownership**
Clear Creek	26.3	91.9
Cooper Creek	15.7	99.4
Crow Creek	14.7	99.5
Dry Creek	32.7	91.4
Lower Prospect	36.5	90.6
Upper Prospect	29.2	98.6
Wilkes Creek	15.2	96.0

2.3 Geology and Soils

The geology of the area is characterized by Belt series metasedimentary rock of middle Proterozoic age (Woessner and Shapley, 1984). Major rocks are comprised of quartzite, siltite, argillite, and dolomite. Surficial deposits of glacial till, outwash, and lacustrine sediments mantle the underlying bedrock. These deposits are overlain by volcanic ash delivered by the eruption of Mt. Mazama in southwestern Oregon approximately 6,800 years ago.

Glaciers occupied tributary valleys in the Lower Clark Fork River basin repeatedly during the Pleistocene Epoch. Unconsolidated rocks in the valley were partly removed and ground up to form a mixture of sandy clay and cobbles, referred to as “till”. Underlying the ice, the till was mounded into terraces and plastered against the lower walls of the Lower Clark Fork River valley. Glacial meltwater carried some of the till southward, sorting and depositing it as outwash in the Prospect Creek valley and as deltaic deposits in the waters of glacial Lake Missoula. Lacustrine sediments deposited during the repeated inundations of the Prospect Creek valley by glacial Lake Missoula form a distinctive soil unit critical to surface water retention in the watershed.

Outwash, material derived from the erosion of till by melt water, forms the coarse-grained deposits comprising terraces in the Prospect Creek drainage. In addition to outwash material, alluvium, which has been eroded from older rocks and deposited by streams and rivers, is prevalent in the basin.

2.4 Climate

The climate of the Prospect Creek drainage is characterized as a combination of modified Pacific maritime and continental climates (USFS, 2000). Annual precipitation totals vary from 23 inches near the confluence of Prospect Creek with the Clark Fork River to about 60 inches at the highest elevations in the watershed (Daly and Taylor, 1998). The nearest weather station, located at the Thompson Falls Dam Powerhouse, has recorded a long-term average precipitation of 23.07 inches per year (NOAA, 2000). January has the highest monthly average precipitation at 2.75 inches and September has the lowest at 1.2 inches (NOAA, 2000). Temperatures in the area are moderate. During the summer months, minimum (night-time) temperatures are in the 50 to 60 degree Fahrenheit (°F) range. Winter cold waves occur, but mild weather is more common.

Temperature and precipitation extremes are more pronounced in the higher elevations of Prospect Creek relative to the Clark Fork Valley floor.

2.5 Topography

The northwest-southeast trending Coeur d'Alene Mountains of the Bitterroot Range are the dominant topographic feature influencing the Prospect Creek watershed. Prospect Creek drainage elevations range from approximately 6,600 feet at the watershed divide, to approximately 2,400 feet at the confluence with the Clark Fork River near Thompson Falls, Montana. The area's topography is a function of the underlying rock types, rock structure, and geologic history.

Alpine glaciation influenced the Prospect Creek watershed similar to other side tributaries in the Lower Clark Fork River drainage. Glacially-derived sediments historically transported by glacial melt-water, and more recently by alluvial processes, filled the valley bottom. Reworking of these materials by Prospect Creek shapes and redistributes sediments.

2.6 Hydrography and Hydrology

Bounded by the Coeur d'Alene Mountains of the Bitterroot Range, Prospect Creek flows in a northeasterly direction before joining the Clark Fork River at the Noxon Reservoir, just downstream from Thompson Falls Dam. Primary tributaries in the drainage include Dry, Clear, Wilkes, and Crow creeks and Cooper Gulch. Multiple smaller tributaries, or gulches, occur throughout the basin and generally reflect seasonal intermittency.

The streamflow regime (i.e. timing, magnitude, and duration), and in particular spring runoff, is periodically influenced by rain-on-snow and rain-on-snowmelt events that can occur anytime during the winter months in response to warm air temperatures and rain. Typically, however, the peak flow event occurs in May or early June.

High magnitude flood events have occurred in the Prospect Creek watershed over the past 40 years, most notably in 1974, 1995-1996, and 1997. These events were attributed to multiple factors including high snowfall and seasonal precipitation, and rain-on-snow events in the spring.

A stream gaging station located above the confluence of Dry Creek has been maintained by the U.S. Geological Survey (#12390700) on Prospect Creek since 1956. Based on the daily records, the mean annual discharge is 244 cfs. A maximum discharge of 5,490 cfs was measured in January 1974. A minimum discharge of 25 cfs was measured on multiple days in February 2001. Recurrence interval flood series flows based on two methods were presented in the Final Prospect Creek Watershed Assessment and Water Quality Restoration Plan (RDG, 2004).

Since RDG, 2004 was completed, the USGS has completed its own flood frequency analysis for gaged streams in Montana (Parrett and Johnson, 2005) using gage records through 1998. These values differ from those presented in RDG, 2004 for several reasons. First, the instantaneous peak flow values presented in RDG, 2004 were based on a modified log-Person Type III distribution which did not include the skew factor typically used by the USGS. Second, the

purpose of the new USGS publication was to develop more refined regression equations based on gage data from Montana and adjacent areas (Parrett and Johnson, 2005) than the equations found in Omang 1992. Finally the watershed area and average annual precipitation values used in RDG 2004 and Parrett and Johnson 2005 varied in the methods used to derive them. RDG 2004 used a planar watershed area above the gage of 169 mi^2 and average annual precipitation of 43.5 inches (based on Daly and Taylor, 1998). The USGS used a planar watershed area of 182 mi^2, which presumably includes the watershed area of Dry Creek, and average annual precipitation of 54 inches from NRCS/SCS 1981 (Parrett and Johnson, 2004). The new USGS analysis included gage records for 43 years up through 1998. Table 2-2 contains the results of the flood frequency analysis reported in Parrett and Johnson 2005 for Prospect Creek.

Table 2-2. Estimated Recurrence Interval Flood Series

From Parrett and Johnson, 2005	
Recurrence Interval (Years)	**Instantaneous Peak Flow Method (cfs)***
Q_2	1,680
Q_5	2,400
Q_{10}	2,880
Q_{25}	3,430
Q_{50}	5,210
Q_{100}	6,940
*Input values include planar watershed area = 182 mi^2 and average annual precipitation = 54 inches.	

Prospect Creek is characterized by both intermittent and perennial flow sections. Stream intermittency may have been exacerbated by sediment deposition linked to the fires of 1889 and 1910 and the large magnitude floods that presumably followed in 1916. Since that time, additional sediment sources and channel disequilibrium in mainstem Prospect Creek have increased sediment production and deposition resulting in aggraded sections of the channel. The effects of this aggradation as a result of these natural and anthropogenic watershed disturbances are reflected in the intermittent nature of Prospect Creek. During summer when surface flows decrease, Prospect Creek becomes intermittent in multiple reaches of up to 2.5 miles in length (Woessner and Shapely, 1987). Surface flows recharge to the alluvial valley groundwater system particularly where valley fill depths are greatest. Groundwater discharge to the channel is typically associated with decreasing valley fill depths and/or semi-impermeable soil layers that force shallow groundwater to the surface.

2.7 Land Use and Population

Land use in the Prospect Creek watershed varies temporally and spatially. In the valley bottoms, land uses have included irrigated pasture, grazing, timber harvest, mining and residential development. Most of the residential homes are located at an elevation higher than the Prospect Creek floodplain. Other land uses watershed-wide include timber harvest, transportation, utility corridors, recreational hunting and fishing, and off-highway vehicle operation. Analyses of timber harvest activity, roads, and utility corridors in the Prospect Creek watershed are detailed in Appendices A and B.

As of the 2000 Montana census, the population of Sanders County totaled 10,227 people. The largest town in the county, Thompson Falls (population 1,319), is located about 6 miles southeast

of Prospect Creek. Prospect Creek also supports uses from traffic originating over the watershed boundary in neighboring Idaho and Washington and elsewhere.

2.8 Vegetation Cover

The Lower Clark Fork River drainage is identified as a moist forest climate. This region is a transitional zone between drier, lower elevation forests and moister, higher subalpine forests. Moist forest types are characterized by high soil moisture in the spring and drought stress through late summer and early fall (USDA, 2000). Historical vegetation composition for the moist forest type consisted of a mixed seral, shade intolerant species composition comprised of western white pine (*Pinus monticola)*, western larch (*Larix occidentalis*), ponderosa pine (*Pinus ponderosa*), and lodgepole pine (*Pinus contorta*).

Natural and human-caused fires have played a role in changing the character of vegetation in the Prospect Creek watershed. The moist forest type was dependent upon a frequent fire return interval to maintain the mixed seral species composition (USDA, 2000). Intense fires in 1889 and 1910 followed by modern fire suppression have resulted in a transition to shade tolerant species and a reduced mixed seral component. Fire suppression has also promoted overstocked stands more prone to intense and severe fires than was historically common.

Vegetation changes have also occurred in response to human activities associated with a variety of land uses including agriculture, grazing and timber harvest as discussed above. In particular, land uses have affected the character of the riparian community.

Riparian Vegetation

Upland and riparian vegetation communities influence the rate of water and sediment delivery to stream channels. Vegetation characteristics such as density, type, and age class play a critical role in channel characteristics including resistance to scour. Large woody debris recruitment influences in-stream sediment storage, channel scour, and fish habitat creation. Accumulations of large woody debris may also provide valuable habitat for wildlife, provide protected areas for vegetation recruitment, and maintain bank integrity. Vegetation removal by harvest or fire may have a large affect on bank integrity as complex root masses are responsible for maintaining bank strength.

Agriculture, grazing, road, utility corridor and pipeline construction, and residential development in the Prospect Creek drainage have been concentrated in the valley bottoms thereby having the greatest affects to vegetation in the riparian community.

2.9 Stream Geomorphology

The channel morphology of Prospect Creek transitions from its headwaters along the Montana-Idaho divide to Prospect Creek's confluence with the Lower Clark Fork River. Topography, basin geology, vegetation condition, and land uses interact to define the channel morphologies observed in Prospect Creek. The primary tributaries in the watershed are influenced similarly.

This section provides a generalized overview of channel morphology and existing stream channel conditions in the Prospect Creek watershed. Detailed assessments are presented in Sections 3.0 and 4.0 of the Phase I Assessment document (RDG, 2004) and in **Appendix F** of this document.

Mainstem Prospect Creek

Mainstem Prospect Creek is a fourth and fifth order stream, approximately 19 miles long from Twentyfour mile Creek to its confluence with the Clark Fork River. The stream channel along the mainstem transitions from a steep, confined Rosgen B reach in the upper watershed to moderate to low gradient Rosgen C reaches through most of the middle and lower watershed. Large inclusions of D reaches are found in the middle and lower watershed where channel instability is greatest as a result of land use activities. A few small inclusions of steeper, more confined B reaches are found in the lower watershed, particularly the reach immediately above the confluence with the Clark Fork River.

The mainstem Prospect Creek has been subject to both natural and human-caused disturbances dating back to the late 19th century. Disturbances have included wildfire, floods, clearing and conversion of riparian vegetation, utility corridor and gas pipeline installation and associated maintenance activities, and highway encroachments. Currently, the middle reaches of Prospect Creek from Clear Creek upstream to Evans Gulch depart from their potential stable state (RDG, 2004). This is reflected in the braided channel condition and altered riparian floristics relative to the historical riparian forest composition.

Appendix F provides additional channel discussion along with a summary of physical parameters.

Clear Creek

Mainstem of Clear Creek is approximately 9 miles long, a fourth order stream, and is the second largest tributary to Prospect Creek. The upper half of Clear Creek mainstem is primarily Rosgen type C reaches with short inclusions of B reaches in steeper, more confined segments. The lower half of Clear Creek mainstem is unconfined and low gradient, with generally alternating C and D reaches.

The Clear Creek watershed encompasses approximately 28 mi^2.USFS manages the land surrounding the upper 6.5 miles of Clear Creek. The lower 2.5 miles flow through privately owned land. Although land uses have changed over time, historic natural and human disturbances have resulted in the greatest watershed impacts. Two large fires between 1880 and 1910 burned a large portion of the watershed resulting in stand replacement. A sheep grazing allotment opened in 1917 took advantage of forage that followed the 1910 fire (USDA, 1997). Initially up to 13,000 sheep grazed the lower Clear Creek watershed. Roads and periodic timber harvest began in the drainage around the beginning of the 20th century. By the mid-1940s, the riparian community inhabiting the Clear Creek valley bottom was characterized by shrub, grass, and scattered tree cover, a substantially different community than the historical condition.

Significant flood events occurred in 1995 and 1996, and evidence suggests a large flood event took place in the mid-1940s. Damage caused by the estimated 50-year flood events in the mid-1990s was repaired in 1997. Channel conditions vary within the Clear Creek drainage based on the influence of historic natural as well as human-caused disturbances. Section 4.0 of the Phase I document (RDG, 2004) provides additional information on existing as well as potential channel conditions in the Clear Creek drainage.

Dry Creek

Mainstem Dry Creek is approximately 6 miles long, a fourth order stream and is the largest tributary to Prospect Creek. Rosgen channel types are generally steeper, confined B reaches with inclusions of A, C and D. Dry Creek enters Prospect Creek near the mouth of Prospect Creek's confluence with the Clark Fork River.

The historical condition of the Dry Creek drainage was likely similar to the Clear Creek drainage. Land use activities including upland and riparian timber harvest, roads, grazing, and residential development modified the historical stream corridor. Similar to Clear Creek, roads and periodic timber harvest began in the late 19th or early 20th centuries. The location of Forest Road 352 necessitates maintenance in response to cutslope failures and direct runoff from the road surface.

Wilkes Creek

Mainstem of Wilkes Creek is approximately 5 miles long, a fourth order stream. Rosgen Channel types in mainstem Wilkes Creek alternate between confined B reaches and moderately confined C reaches.

Wilkes Creek enters Prospect Creek in the lower portion of the middle watershed. Wilkes Creek is the third largest tributary (similar in size to Cooper Gulch) in the Prospect Creek drainage, measuring approximately 15.8 square miles. Similar to other tributaries, Wilkes Creek experiences localized intermittency related to channel aggradation.

Wilkes Creek, flowing through the upper private in-holding is in near reference conditions. The stream corridor in the lower watershed exhibits the effects of channel modification from both natural and human-caused activities. A series of headcuts located on private land have likely formed due to lowering of the base elevation of the mainstem Prospect Creek.

Crow Creek

Mainstem of Crow Creek is a fourth order stream, approximately 2 miles long. Rosgen channel types on the mainstem of Crow Creek are primarily C reaches with a long F inclusion below the confluence of the East and West Forks.

Bonneville Power Administration (BPA) transmission lines extend up the Crow Creek valley bottom County Highway No. 471 to the confluence of the East and West Forks Crow Creek. At

the confluence of the forks, the BPA line follows the ridge dividing the watersheds of the forks to the Crow Creek divide where it crosses into the St. Regis watershed to the south.

Cooper Gulch

Cooper Gulch is approximately 7 miles long and is a fourth order tributary to Prospect Creek. Rosgen channel types along Cooper Creek include confined B reaches and moderately confined C reaches. Portions of Lower Cooper Gulch are classified as D and F reaches.

Northwestern Energy power lines and FSR 7623 extend up the Cooper Gulch valley bottom from County Highway No. 471 to the Montana-Idaho border at Cooper Pass. Spokane, Chipmunk, and Summit Creeks are major second order tributaries to Cooper Gulch.

2.10 Fisheries and Aquatic Life

The Phase I document Section 2.8 (RDG, 2004) discusses fisheries and aquatic macroinvertebrates in the Prospect Creek watershed. In addition, the most recent Avista fisheries report presents fish abundance results for 2003 (Moran, 2004). **Appendix D** of this document includes a synopsis of these documents as well as new information including additional Montana Department of Environmental Quality (DEQ[1]) macroinvertebrate sampling results.

[1] The acronym DEQ refers to the Montana Department of Environmental Quality unless otherwise noted.

SECTION 3.0
TMDL REGULATORY FRAMEWORK

This section of the Prospect Creek watershed water quality restoration plan describes the applicable water quality standards, and reviews the water quality and water use-support status of Prospect Creek basin streams in relation to those standards. A review of the available water quality data is also provided for each threatened or impaired stream segment.

3.1 TMDL Development Requirements

Waters of the State of Montana must fully support beneficial uses associated with their classification and water quality standards (MCA 75-5-703, ARM 17.30.606-614, and 17.30.620-629). Beneficial water uses that apply to all Montana water bodies include cold or warm water fisheries, aquatic life, drinking water, contact recreation (e.g. swimming), and agricultural and industrial uses. DEQ determines the level of beneficial use-support of surface waters according to the following definitions:

> *A use is fully supported when all water quality standards applicable to that use are met. When one or more standards are not met due to human activities, the water body is either "not supporting" or "partially supporting" the beneficial use tied to that standard. A use that is currently fully supported but for which observed trends or proposed new sources of pollution indicate a high probability of future impairment may be rated as "threatened." Because the standards for determining use support are different for each use, the use-support determinations for the various uses of a waterbody are often not the same. Only those beneficial uses that apply to the particular water-use classification of a waterbody are evaluated for that waterbody* (DEQ, 2004a).

Water bodies that do not support, or are unlikely to support, all of their designated beneficial uses due to other than natural causes are classified as “water quality-limited” and are summarized on the Montana 303(d) List prepared by the DEQ[2]. 303(d) refers to a section of the federal Clean Water Act, which describes surface water quality monitoring and assessment requirements. The Montana 303(d) List provides a report of impaired and threatened water bodies in need of TMDLs for those impairment or threatened conditions that are linked to pollutants. These TMDLs, along with additional planning to address non-pollutant causes of impairment, will ensure the full support of all beneficial uses when implemented. The 303(d) List includes identification of the probable cause(s) of the water quality impairment problems (e.g. pollutants such as sediment, metals, or nutrients), and the suspected source(s) of the pollutants of concern (e.g. various land use activities). The Montana 303(d) List is published biennially.

Prior to 2004, a 305(b) Report documenting waters listed as fully supporting beneficial uses and waters that lacked sufficient credible data was published along with the 303(d) List. In 2006, the 303(d) List was combined with the 305(b) Report into the *2006 Montana Water Quality Integrated Report*. The 2006 Integrated Report reflects water quality assessments conducted by

[2] DEQ refers to the Montana Department of Environmental Quality unless otherwise noted.

the DEQ as of December 2005. The 2006 Integrated Report incorporates new guidance from the United States Environmental Protection Agency (EPA) which requires total maximum daily loads (TMDLs) be developed for waters impaired by “pollutants,” such as nutrients, sediment, or metals. TMDLs are not required for waters impaired solely by “pollution,” such as flow alterations or habitat degradation (DEQ, 2004a).

Water bodies appearing on the 1996 and 1998 303(d) Lists were subsequently re-evaluated using more rigorous review criteria during the preparation of the 2000 and 2002 303(d) Lists and, most recently, the 2006 Integrated Report. The review criteria were revised as a result of 1997 amendments to the Montana Water Quality Act pertaining to the 303(d) Listing and water quality restoration planning processes. The 1997 changes require the consideration of “all currently available data,” and a determination that adequate data of sufficient quality are available for a particular stream, before a 303(d)-listing decision can be made. DEQ has developed specific decision criteria for evaluating “sufficient credible data” and for making “beneficial use determinations” (DEQ, 2006). Sufficient credible data (SCD) is defined under Montana Law as *"chemical, physical, or biological monitoring data, alone or in combination with narrative information, that supports a finding as to whether a water body is achieving compliance with applicable water quality standards"* (75-5-103 MCA).

The 2006 303(d) List is the most recently approved by DEQ, but by federal court order DEQ must also address all pollutant waterbody combinations appearing on the 1996 303(d) list. Total Maximum Daily Loads must be developed for all pollutants appearing on either the 2006 and 1996 303(d) Lists, except where the later listing represents a refinement of the original listing (based on sufficient and credible data). The sufficient credible data indicates that the basis for the original listing was in error, or that water quality standards are presently being attained and a listing is no longer valid. Sufficient credible data was assessed for all streams in the Prospect Creek watershed appearing on the 1996 303(d) list and is reflected in the listings on the 2006 303(d) list.

3.2 Water Bodies and Pollutants of Concern

A Prospect Creek TMDL planning area has been established by DEQ. A total of three individual stream segments in the Prospect Creek watershed were identified as impaired on the 1996 303(d) List, while five segments were identified as impaired on the 2006 303(d) List (**Table 3-1, Figure 2-1)**. As mentioned earlier in this section, all necessary TMDLs must be completed for all pollutant/water body combinations identified on the 1996 303(d) List. TMDLs are not required for pollutant waterbody combinations that are not *listed*, but may be developed at the discretion of the DEQ. Although not listed for sediment in 1996 nor 2006, in this case, data and information for Prospect Creek and Dry Creek justifies completing sediment TMDLs for these waterbodies. Clear Creek was listed for sediment/siltation in 2006 and has been addressed via TMDL in this document, as well.

Table 3-1. Stream Segments in the Prospect Creek TMDL Planning Area that Appear on Montana's 303(D) List of Impaired Waters, and Their Associated Levels of Beneficial Use-Support

Water body & Stream Description	Water body #	Use Class	Year	Aquatic Life	Coldwater Fishery	Drinking Water	Swimmable (Recreation)	Agriculture	Industry
Prospect Creek	MT76N003-020	B-1	1996	-	T	-	-	-	-
			2006	N	N	N	F	F	F
Clear Creek	MT76N003-070	B-1	1996	-	T	-	-	-	-
			2006	P	P	F	F	F	F
Dry Creek	MT76N003-050	B-1	1996	-	T	-	-	-	-
			2006	P	P	F	P	F	F
Antimony Creek	MT76N003-021	B-1	1996	X	X	X	X	X	X
			2006	N	N	N	X	X	X
Cox Gulch	MT76N003-022	B-1	1996	X	X	X	X	X	X
			2006	N	N	N	X	N	X
F= Full Support; **P**= Partial Support; **N**= Not Supported; **T**= Threatened; **X** = Not Assessed.									

Table 3-2. Probable Causes and Sources of Impairment for 303(D)-Listed Stream Segments in the Prospect Creek TMDL Planning Area

Water body	1996 Causes	1996 Sources	2006 Causes	2006 Sources
Prospect Creek	Flow Alterations	Agriculture; Silviculture	Alteration in stream-side or littoral vegetative covers	Grazing in Riparian or Shoreline Zones; Silviculture Activities
	Other Habitat Alterations		Antimony	Mine Tailings
	Thermal Modifications		Lead	Mine Tailings
			Zinc	Mine Tailings
Clear Creek	Flow Alterations	Land Development	Sedimentation/Siltation	Forest Roads (Road Construction and Use); Streambank Modifications/Destabilization
			Alteration in stream-side or littoral vegetative covers	Streambank Modifications/Destabilization
Dry Creek	Flow Alterations	Highway/Bridge/Road Construction	Alteration in stream-side or littoral vegetative covers	Highways, Roads, Bridges, Infrasturcture (New Construction) Rangeland Grazing
	Other Habitat Alterations		Chlorophyll a	Rangeland Grazing
Antimony Creek	N/A	N/A	Arsenic	Mill Tailings
			Lead	Mill Tailings
Cox Gulch	N/A	N/A	Lead	Mill Tailings
			Zinc	Mill Tailings

3.3 Applicable Water Quality Standards

Water quality standards include the uses designated for a water body, the legally enforceable standards that ensure that the uses are supported, and a non-degradation policy that protects the high quality of a water body. The ultimate goal of this water quality restoration plan, once implemented, is to help ensure that all designated beneficial uses are fully supported and all standards are met for streams in the Prospect Creek watershed, particularly those identified as impaired on the 303(d) List. Water quality standards form the basis for the targets described in **Section 4.0**. Pollutants addressed in this Water Quality Restoration Plan include sediment and thermal modifications. This section provides a summary of the applicable water quality standards for each of these pollutants.

3.3.1 Classification and Beneficial Uses

Classification is the assignment (designation) of a single use or group of uses to a water body based on the potential of the water body to support those uses. Designated Uses or Beneficial Uses are simple narrative descriptions of water quality expectations or water quality goals. There are a variety of "uses" of state waters including growth and propagation of fish and associated aquatic life, drinking water, agriculture, industrial supply, and recreation and wildlife. The Montana Water Quality Act (WQA) directs the Board of Environmental Review (BER, i.e., the state) to establish a classification system for all waters of the state that includes their present (when the Act was originally written) and future most beneficial uses (Administrative Rules of Montana (ARM) 17.30.607-616) and to adopt standards to protect those uses (ARM 17.30.620-670).

Montana, unlike many other states, uses a watershed based classification system with some specific exceptions. As a result, *all* waters of the state are classified and have designated uses and supporting standards. All classifications have multiple uses and in only one case (A-Closed) is a specific use (drinking water) given preference over the other designated uses. Some waters may not actually be used for a specific designated use, for example as a public drinking water supply; however, the quality of that water body must be maintained suitable for that designated use. When natural conditions limit or preclude a designated use, permitted point source discharges or non-point source discharges may not make the natural conditions worse.

Modification of classifications or standards that would lower a water's classification or a standard (i.e., B-1 to a B-3), or removal of a designated use because of natural conditions can only occur if the water was originally misclassified. All such modifications must be approved by the BER, and are undertaken via a Use Attainability Analysis (UAA) that must meet EPA requirements (40 CFR 131.10(g), (h), and (j)). The UAA and findings presented to the BER during rulemaking must prove that the modification is correct and all existing uses are supported. An existing use cannot be removed or made less stringent.

Descriptions of Montana's surface water classifications and designated beneficial uses are presented in **Table 3-3.** Within the Prospect Creek TPA, all listed streams are classified as B-1.

Table 3-3. Montana Surface Water Classifications and Designated Beneficial Uses

Classification	Designated Uses
B-1 CLASSIFICATION:	Waters classified B-1 are to be maintained suitable for drinking, culinary and food processing purposes after conventional treatment; bathing, swimming and recreation; growth and propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

3.3.2 Standards

In addition to the Use Classifications described above, Montana's water quality standards include numeric and narrative criteria as well as a nondegradation policy that currently applies to the numeric criteria.

Numeric surface water quality standards have been developed for many parameters to protect human health and aquatic life. These standards are in the Department Circular WQB-7 (DEQ, 2004). The numeric human health standards have been developed for parameters determined to be toxic, carcinogenic, or harmful and have been established at levels to be protective of long-term (i.e., life long) exposures, as well as through direct contact such as swimming.

The numeric aquatic life standards include chronic and acute values that are based on extensive laboratory studies including a wide variety of potentially affected species, a variety of life stages, and durations of exposure. Chronic aquatic life standards are protective of long-term exposure to a parameter. The protection afforded by the chronic standards includes reproduction, early life stage survival, and growth rates. In most cases the chronic standard is more stringent than the corresponding acute standard. Acute aquatic life standards are protective of short-term exposures to a parameter, and are not to be exceeded.

High quality waters are afforded an additional level of protection by the nondegradation rules (ARM 17.30.701 et. seq.,) and in statute (75-5-303 MCA). Changes in water quality must be "non-significant" or an authorization to degrade must be granted by the Department. However under no circumstance may standards be exceeded. It is important to note that waters that meet or are of better quality than a standard are high quality for that parameter, and nondegradation policies apply to new or increased discharges to that the water body.

Narrative standards have been developed for substances or conditions for which sufficient information does not exist to develop specific numeric state wide standards. The term "Narrative Standards" commonly refers to the General Prohibitions in ARM 17.30.637 and other descriptive portions of the surface water quality standards. The General Prohibitions are also called the "free from" standards; that is, the surface waters of the state must be free from substances attributable to discharges, including thermal pollution, that impair the beneficial uses of a water body. Uses may be impaired by toxic or harmful conditions (from one or a combination of parameters) or conditions that produce undesirable aquatic life. Undesirable aquatic life includes bacteria, fungi and algae.

The standards applicable to the list of pollutants addressed in the Prospect Creek TPA are summarized below.

3.3.2.1 Sediment Standards

Sediment (i.e., coarse and fine bed sediment) and suspended sediment are addressed via the narrative criteria identified in **Table 3-4.** The relevant narrative criteria do not allow for harmful or other undesirable conditions related to increases above naturally occurring levels or from discharges to state surface waters. This is interpreted to mean that water quality goals should strive toward a condition in which any increases in sediment above naturally occurring levels are not harmful, detrimental, or injurious to beneficial uses (see definitions in **Table 3-4**).

Table 3-4. Applicable Rules and Definitions for Sediment Related Pollutants

Rule(s)	Standard
17.30.602(28)	"Sediment" means solid material settled from suspension in a liquid; mineral or organic solid material that is being transported or has been moved from its site of origin by air, water or ice and has come to rest on the earth's surface, either above or below sea level; or inorganic or organic particles originating from weathering, chemical precipitation or biological activity.
17.30.602(19)	"Naturally occurring" means conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil, and water conservation practices have been applied. Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971 are natural.
17.30.602(24)	"Reasonable land, soil, and water conservation practices" means methods, measures, or practices that protect present and reasonably anticipated beneficial uses. These practices include but are not limited to structural and nonstructural controls and operation and maintenance procedures. Appropriate practices may be applied before, during, or after pollution-producing activities.
17.30.622(3) & 17.30.623(2)	No person may violate the following specific water quality standards for waters classified A-1 or B-1.
17.30.622(3)(f) & 17.30.623(2)(f)	No increases are allowed above naturally occurring concentrations of sediment or suspended sediment (except a permitted in 75-5-318, MCA), settleable solids, oils, or floating solids, which will or are likely to create a nuisance or render the waters harmful, detrimental, or injurious to public health, recreation, safety, welfare, livestock, wild animals, birds, fish, or other wildlife.
17.30.622(3)(d)	No increase above naturally occurring turbidity or suspended sediment is allowed in A-1 except as permitted in 75-5-318, MCA.
17.30.623(2)(d)	The maximum allowable increase above naturally occurring turbidity is 5 NTU for B-1 except as permitted in 75-5-318, MCA.
17.30.637(1) (a & d)	State surface waters must be free from substances attributable to municipal, industrial, agricultural practices or other discharges that will: (a) settle to form objectionable sludge deposits or emulsions beneath the surface of the water or upon adjoining shorelines; (d) create concentrations or combinations of materials which are toxic or harmful to human, animal, plant or aquatic life.

SECTION 4.0
EXISTING STREAM CONDITIONS, TARGETS, DEPARTURE ANALYSIS AND WATER QUALITY SUMMARY

This section provides updated water quality summaries for the Prospect Creek Planning Area. Numerous pieces of information are often necessary to adequately evaluate water quality. Water quality assessments involve several steps. The first step involves identifying water quality reference values using the guidance presented in **Section 3.0** and **Appendix G**. The second step is to develop TMDL targets and beneficial use support objectives based on the identified reference conditions. The third step, also known as departure analysis, is to evaluate existing stream conditions against targets and objectives. Water quality assessments are based on the results of departure analysis.

Section 4.1 provides an introductory discussion on reference values, TMDL targets, beneficial use support objectives, and considerations for natural variability and adaptive management. **Section 4.2** presents each parameter used to assess existing stream conditions. The importance of each parameter to beneficial use support conditions and linkages to water quality standards are described. Existing Prospect Creek Watershed data are presented and are compared to targets and use support objectives (departure analysis). Finally, water quality summaries for the Prospect Creek Planning Area are provided in **Section 4.3**.

4.1 Introduction

4.1.1 Reference Value Development

Reference development **(Appendix G)** is focused on those parameters that can be linked closely to the beneficial use support (**Figure 4-1**). Ideally, the best parameters would include robust measures of fishery and aquatic life from reference water bodies where all sediment and habitat conditions are functioning at their potential given historic land uses and the application of all reasonable land, soil and water conservation practices. There has been and continues to be significant progress toward the development of macroinvertebrate and periphyton reference values throughout Montana. These reference values, along with reference values for habitat parameters such as percent fines, can provide vital information to make aquatic life beneficial use determinations. On the other hand, a robust reference data set to represent the primary species of cold-water fish found in the Prospect Creek Watershed represents a difficult challenge given the multitude of variables that can influence fishery data. For this reason, cold-water fish beneficial use support decisions linked to sediment and habitat impairments often rely on fish habitat and channel condition parameters because of the impact that these parameters, represented within **Figure 4-1**, can have on fishery health.

Reference values were identified for the following parameters to help determine impact to cold water-fish and/or aquatic life:

- Percent Surface Fines in Riffles < 6.35 mm (pebble count)
- Percent Surface Fines < 6.35 mm in Pool Tails and Riffles (grid toss or equivalent)

- Percent Substrate Fines in Pool Tails < 6.35 mm (McNeil cores)
- Pool Frequency (number of pools per unit length)
- Width to Depth Ratio (ratio of bankfull width to bankfull depth at riffle cross sections)
- Sinuosity
- Riffle Stability Index
- Large Woody Debris (amount of large woody debris per unit length)
- Riparian Vegetation
- Macroinvertebrate Populations

The above parameters cover a broad range of direct habitat measures and measures of channel conditions, as well as a direct measure of aquatic life (macroinvertebrate metrics). All of the above parameters are measures of sediment-related impacts. Reference value development for each of the parameters is presented in **Appendix G.**

Given the potential widespread historical human impacts throughout the Prospect Creek Watershed, the use of internal reference values from within the watershed for reference development cannot be justified for many parameters, and historical data is not available for many parameters. This leaves the use of regional reference data as a remaining primary approach used in many of the following sections. Focus is on the use of regional reference data supplemented by some internal Prospect Creek Watershed data and secondary reference development approaches.

Management activities, natural events, watershed and riparian processes, and stream inputs such as sediment loading all play an important role in assessing the condition of a waterbody **(Figure 4-1)**. Most of these must be considered when evaluating the applicability of reference values, assessing water quality, and when applying the adaptive management approach discussed in **Section 4.1.4**. This includes consideration of historical land use and linkages to sediment loading and habitat impacts, as well as consideration of anticipated natural variability as part of the process of selecting, developing and applying reference parameters to the Prospect Creek Watershed.

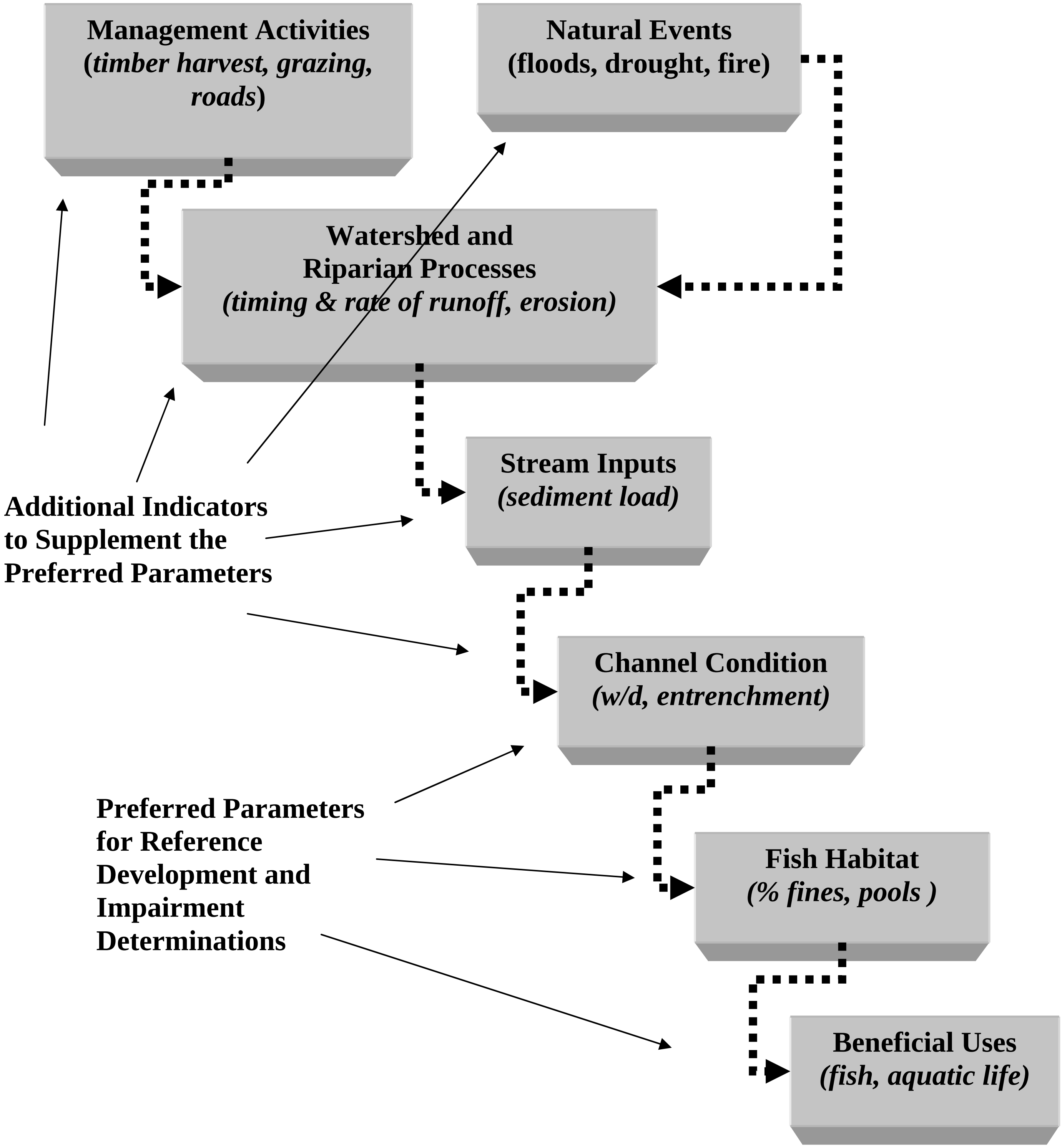


Figure 4-1. How Various Measures and Potential Reference Parameters Fit in the Watershed Cause and Effect Pathway for Sediment and Habitat Measures

4.1.2 TMDL Targets

This section presents beneficial use support objectives, or "TMDL targets", for the Prospect Creek Watershed. These targets are numeric or measurable values that represent desired conditions and achievement of water quality standards, both numeric and narrative, for a waterbody. Since narrative standards apply to the impairments **(Section 3.0)**, the TMDL targets are based on reference conditions developed in **Appendix G**. Sediment, habitat and flow impairments are the focus of the beneficial use support objectives. The beneficial use objectives also represent the water quality endpoints by which the ultimate success of implementation of this plan will depend upon.

A range of targets is developed to address potential sediment impairment conditions using several indicator parameters. Per EPA sediment guidance (EPA, 1999) it is stated that "in many watersheds more than one indicator and associated numeric target might be appropriate to account for process complexity and the potential lack of certainty regarding the effectiveness of an individual indicator."

Targets fall within two general categories in this document as described below. All targets are developed for sediment, with consideration of both fine and coarse or total sediment impairment indicators.

1. Primary Targets: Primary targets must be satisfied under most conditions to ensure full support of the beneficial use. Not meeting a Primary target means likely impact to one or more beneficial use, as long as the application of this target is strengthened by supporting indicators that can be linked to sources of pollutant loading at a minimum. Indicator parameters used for developing Primary targets include pool frequency, percent fines < 6.35 mm in riffles (pebble count), percent subsurface fines (McNeil core), and macroinvertebrate metrics.
2. Supporting Targets: Supporting targets can be used to assist with the assessment of water quality. There is more flexibility with the application of these targets. The Supporting targets can be used as substitutes for Primary targets under some conditions, such as where Primary target data is lacking for a given stream segment and it is determined that meeting or not meeting Supporting targets provides sufficient information to assess the stream. Where sufficient Primary target data is available, a Supporting Target may be used to reinforce the conclusions based on the primary target. Indicator parameters used for developing Supporting targets include width to depth ratio, grid toss fines, and pebble count percent fines.

Primary and Supporting targets provide evidence, and/or collaborative information when used in combination, to indicate that Montana's sediment related water quality standards are not met. Not meeting one particular target, primary or supporting, does not necessarily mean sediment standards are not met. However, some target exceedances can be directly linked to a standard exceedence when weighed along with supporting target data, known sediment sources, and other available information about stream and watershed health. Subsequent data or information can also help refine targets through time as part of the adaptive management approach and can help determine whether or not meeting one or more targets is a result of natural versus human causes.

Supporting targets do not necessarily require development of a reference or numeric value, although development of a reference value or a value that indicates relatively high levels of human impact, is often desirable. Supporting targets may also include values for large woody debris, sinuosity, meander length ratio, bull trout redd levels, and residual pool depth. Several additional supporting targets that may be without a reference or numeric values may include sediment loading information and sources, visual indicators of in-channel sediment or stream stability, and other fish data.

Each target includes a rationale and applicability considerations. Because of the adaptive management considerations discussed below, all targets developed in this document are subject to potential modification and further interpretations through time, with the DEQ taking a lead or needing to approve any modifications. **Appendix G** provides reference and target development details. **Table 4-1** provides a summary of the targets.

When target application is specified by stream type, targets apply to the most probable, stable stream type of the reach in question. For example, targets for C stream types will also be applied to a reach where the existing condition is a D stream type but under most probable, stable, functioning conditions the reach would be a C stream type.

Table 4-1. Summary of Sediment TMDL Targets

Parameter	Target Type	Value	How Applied	How Measured
Percent Surface Fines < 6.35 mm in Riffles	Primary	< 15%	All reaches	Wolman Pebble Count
Percent Surface Fines < 6.35 mm in Pool Tails and Riffles	Primary	< 10%	All reaches	Grid Toss or Equivalent (e.g. viewing bucket)
Percent Substrate Fines < 6.35 mm	Primary	< 15%	All streams where spawning occurs in pool tail areas	McNeil Core
Pool Frequency	Primary	> 26 > 47-66	Prospect Creek main stem B and C stream types Tributary B and C stream types	Longitudinal Profile
Width-to-Depth Ratio	Supporting	< 30 < 20	Prospect Creek main stem B and C stream types Tributary B and C stream types	Standard Bankfull Cross Section Measures
Sinuosity	Supporting	1.2 – 1.4	All B and C stream types	Standard aerial assessment
Riffle Stability Index	Supporting	40-70	All B and C stream types	Method established by Kappesser
Large Woody Debris	Supporting	Refer to Table 4-9	By stream width, stream order, Rosgen stream types	R1/R4 Method or Equivalent
Riparian Vegetation	Supporting	60% canopy density in riparian areas of the lower reaches of	Lower reaches are considered those reaches of Prospect Creek where active channel widths are > 75’	% density; shade with densitometer

Table 4-1. Summary of Sediment TMDL Targets

Parameter	Target Type	Value	How Applied	How Measured
		Prospect Creek; 75% canopy density in riparian areas of the upper reaches of Prospect Creek	(Reaches 2-4). Upper reaches are those reaches of Prospect Creek where active channel widths are <75' (Reaches 4-5).	
Macroinvertebrate Populations	Supporting	Acceptable metrics per DEQ protocol	All reaches (focus on riffles)	Standard DEQ protocols

4.1.3 Natural Variability

The targets established in this section all apply under normal or median type conditions of natural background loading and natural disturbance. It is recognized that under some natural conditions such as a large fire or flood events, it may be impossible to satisfy some of the targets until the stream and/or the watershed recovers from the natural event. The goal, under these conditions, will be to ensure that management activities within the watershed or individual tributaries are undertaken in such a way that the achievement of targets is not significantly delayed compared to natural recovery. Another goal will be that human activities do not significantly increase the extent of negative water quality or habitat impacts from natural events during the recovery period. Human activities within the Prospect Creek Watershed that are lacking application of reasonable land, soil and water conservation practices, or have historically occurred without the application of these practices, cannot be defined as a natural disturbance or as naturally occurring.

It is recognized that natural disturbance pulses can be a positive influence toward the creation and maintenance of habitat features such as pools or LWD. In fact, some significant flood or other types of natural disturbances may be necessary to eventually meet target conditions. For example, flood flows may be necessary to help move excess bedload size material through the system under conditions where width to depth and other stream morphology conditions can effectively transport excess material. In some systems, flood flows interact with LWD to create pool and other desirable habitat features.

4.1.4 Adaptive Management

Adaptive management is applied toward the water quality goals defined within this section. For the purpose of this document, adaptive management relies on continued monitoring of water quality and stream habitat conditions, continued assessment of impacts that human activities and natural conditions have on water quality and stream habitat conditions, and continued assessment of how aquatic life and cold-water fish, particularly bull trout and cutthroat trout, respond to changes in water quality and stream habitat conditions. Adaptive management addresses important considerations such as feasibility and uncertainty in establishment of targets. For example, despite implementation of all restoration activities (**Sections 7.0 and 8.0**), the attainment of targets may not be feasible due to natural disturbance such as forest fires, flood events, or landslides. Similarly, it is possible that the natural potential of some streams will

preclude achievement of some targets. For instance, natural geologic and other conditions may contribute sediment at levels that cause a deviation from numeric targets associated with sediment. Conversely, some targets may be underestimates of the potential of a given stream and it may be appropriate to apply more protective targets upon further evaluations. Supplemental indicators are used to help with these determinations. In light of all this, it is important to recognize that the adaptive management approach provides the flexibility to refine targets as necessary to ensure protection of the resource or to adapt to new information concerning target achievability.

As part of this adaptive management approach, increased land use activities should be tracked along with increased monitoring of target parameters before and after land use activities should always be considered. The extent of monitoring should be consistent with the extent of potential impacts, and can vary from basic BMP compliance inspections to a complete measure of target parameters below the project area before the project and after completion of the project. Cumulative impacts from multiple projects must also be a consideration. This approach will help track the recovery of the system and the impacts, or lack of impacts, from ongoing management activities in the watershed. Under these circumstances, additional targets and other types of water quality goals may need to be developed to address new stressors to the system, depending on the nature of the activity.

4.2 Targets, Existing Conditions and Departure Analysis

Target values were selected from reference values presented in **Appendix G**. In this section the targets and objectives are presented for each parameter followed by a discussion of the importance of each parameter (rationale) as it relates to water quality standards. Applicability considerations are also discussed. Existing stream condition data from **Appendix F** are presented and compared to the selected targets values and use support objectives. These comparisons are made for Prospect Creek as well as the tributary streams to Prospect Creek.

Parameters used as primary sediment targets include percent surface fines < 6.35 mm (pebble count and grid toss), percent substrate fines < 6.35 mm (McNeil Core), and pool frequency. Parameters used as supporting sediment targets include width-to-depth ratio, sinuosity, riffle stability index, large woody debris, riparian vegetation, macroinvertebrate populations, and fish data.

4.2.1 Sediment-Related Parameters

Excess fine sediment is typically referred to as a “siltation” cause of impairment on Montana’s 303(d) list, with potential impacts often relating to excess subsurface fines in spawning gravels or excess surface fines in riffles. Excessive surface and substrate fines may limit fish egg and embryo survival. Macroinvertebrate richness may also be limited by excess surface fines, thus limiting aquatic life and potentially having a negative impact on cold-water fish that rely on macroinvertebrates as a food source (Suttle et al., 2004).

Fine sediment on the channel bed surface and within the channel substrate may be evaluated in several ways. McNeil core samples may be used to determine the percent of fines in the upper

several inches of channel substrate, usually in pool tail outs where fish spawning is likely to occur. The 49-point grid toss method may be used to determine percent surface fines < 6.35 mm at pool tail outs and riffles, although data from pool tail outs is used in this document. Pebble counts may also be used to evaluate surface fines in riffles and pools. Grid-toss and pebble count measures of surface fines can also be used as surrogates for assessing substrate fines. For pool tail outs, McNeil coring is believed to be a more consistent method for evaluating the impacts of fines on spawning success than the grid-toss method, and is therefore a preferred method. McNeil core data were not available for the Prospect Creek Watershed, although McNeil core data are identified as a primary target related to sediment impairments.

4.2.1.1 Percent Surface Fines < 6.35 mm in Riffles (pebble counts)

Primary Sediment Target:
Less than 15% surface fines less than 6.35 mm in riffles based on Wolman pebble counts.

Rationale:
This target encompasses particle size classes less than 2 mm as well as less than 6.35 mm. Development of this target is one of the important criteria for evaluating whether or not excess sediment loading indicates a "siltation" or excess fine sediment type of impairment cause. The target values are based on the reference indicators developed in **Appendix G**.

Applicability Considerations:
Not meeting this target suggests a fine sediment impact to aquatic life and possibly cold water fish. Where the target value is not met, the stream is potentially impaired unless there is appropriate evidence, including macroinvertebrate results from the same area, to otherwise suggest that the high level of fines is not negatively affecting aquatic life. The target also helps with use support determinations in areas where McNeil Core data is lacking to evaluate substrate fines in fish spawning areas.

Where there are multiple representative samples in a reach, meeting the target value with 75% or more of the pebble count results may be acceptable as long as there are acceptable macroinvertebrate results from at least one or more areas with elevated fine sediment. Part of the reason for allowing this flexibility is the inherent variability in pebble count results, particularly at the low range of sediment sizes. Another reason is due to the fact that the macroinvertebrate samples are a more direct measure of beneficial use based on developed reference approaches.

The grid toss target can apply in areas where pebble count data are lacking.

Existing Conditions and Departure Analysis:
Results of percent surface fines < 6.35 mm in riffles based on pebble counts indicate that percent surface fines in riffles of mainstem Prospect Creek generally meet the target **(Table 4-2)**. Exceptions include one site in Reach 2, and two sites in Reach 5. Most tributary sites also meet the target. Exceptions include Clear Creek Reaches 4 and 8, all Dry Creek reaches, except for the steep A reach, the upper three reaches in Wilkes Creek, the upper reaches in Crow Creek including the East Fork and West Fork reaches, and Reaches 3 and 4 in Cooper Creek.

Table 4-2. Percent Surface Fines <6.35 mm in Riffles from Pebble Count Results (RDG and USFS 2003 data) and Comparison to Target Values

Water Body	Surveyor	Reach	Rosgen Stream Type	Feature	% Fines < 6.4 mm	Target	Departure from Target	Target Comparison
Main Stem	RDG	R1, XS1	B3c/F3	riffle	13	<15	-2	Meets Target
Main Stem	RDG	**R2, XS1**	D4	riffle	**20**	<15	**+5**	**Above Target**
Main Stem	RDG	R2, XS3	C4	riffle	13	<15	-2	Meets Target
Main Stem	RDG	"Ref" C, XS1	Ref C4	riffle	12	<15	-3	Meets Target
Main Stem	RDG	"Ref" C, XS2	Ref C4	riffle	8	<15	-7	Meets Target
Main Stem	RDG	R3, XS1	C3	riffle	1	<15	-14	Meets Target
Main Stem	RDG	R3, XS2	D4	braid	6	<15	-9	Meets Target
Main Stem	RDG	R3, XS3	D4	braid	11	<15	-4	Meets Target
Main Stem	RDG	R3, XS4	C4	riffle	6	<15	-9	Meets Target
Main Stem	RDG	R4, XS1	D4	braid	12	<15	-3	Meets Target
Main Stem	RDG	R4, XS2	D3	braid	3	<15	-12	Meets Target
Main Stem	RDG	R4, XS3	D4b	riffle	8	<15	-7	Meets Target
Main Stem	LNF	**R5, XS1, (FS R4)**	C	riffle	**17**	<15	**+2**	**Above Target**
Main Stem	LNF	**R5, XS2, (FS R4)**	C	riffle	**18**	<15	**+3**	**Above Target**
Main Stem	LNF	R5, (FS R3)	C	riffle	5	<15	-10	Meets Target
Main Stem	LNF	R6, (FS R1)	B	riffle	14	<15	-1	Meets Target
Clear Creek	RDG	R1, XS1	C4	riffle	8	<15	-7	Meets Target
Clear Creek	RDG	R1, XS2	C4	riffle	10	<15	-5	Meets Target
Clear Creek	RDG	R3	C4	riffle	12	<15	-3	Meets Target
Clear Creek	RDG	**R4**	D4	braid	**35**	<15	**+20**	**Above Target**
Clear Creek	LNF	R6, (FS R2)	C	riffle	7	<15	-8	Meets Target
Clear Creek	LNF	**R8, (FS R2b)**	C	riffle	**20**	<15	**+5**	**Above Target**
Dry Creek	RDG	**R1**	C4	riffle	**20**	<15	**+5**	**Above Target**
Dry Creek	RDG	R2	A3	riffle	6	<15	-9	Meets Target
Dry Creek	RDG	**R3**	C4	riffle	**17**	<15	**+2**	**Above Target**
Dry Creek	RDG	**R4, WF**	D4b	braid	**22**	<15	**+7**	**Above Target**
Dry Creek	RDG	**R4, EF**	D4b	braid	**35**	<15	**+20**	**Above Target**
Dry Creek	RDG	**R5, WF**	Ref B4	riffle	**18**	<15	**+3**	**Above Target**
Dry Creek	LNF	**R3, (FS R1)**	C4	riffle	**18**	<15	**+3**	**Above Target**
Dry Creek	LNF	**EF**	C4	riffle	**37**	<15	**+22**	**Above Target**
Dry Creek	LNF	**WF**	B4	riffle	**34**	<15	**+19**	**Above Target**
Wilkes Creek	RDG	R1	B4c	riffle	9	<15	-6	Meets Target
Wilkes Creek	RDG	R2	C4	riffle	13	<15	-2	Meets Target
Wilkes Creek	RDG	**R3**	B4c	riffle	**16**	<15	**+1**	**Above Target**
Wilkes Creek	LNF	**R2, XS1**	C4	riffle	**19**	<15	**+4**	**Above Target**
Wilkes Creek	LNF	**R2, XS2**	C4	riffle	**23**	<15	**+8**	**Above Target**
Crow Creek	LNF	R2, XS1	C3/4	riffle	14	<15	-1	Meets Target
Crow Creek	LNF	**R2, XS2**	C3/4	riffle	**20**	<15	**+5**	**Above Target**
Crow Creek	LNF	**R1, EF, XS1**	C4b	riffle	**24**	<15	**+9**	**Above Target**
Crow Creek	LNF	**R1, EF, XS2**	C4b	riffle	**30**	<15	**+15**	**Above Target**
Crow Creek	LNF	**R1, WF XS1**	C4b	riffle	**38**	<15	**+23**	**Above Target**

Table 4-2. Percent Surface Fines <6.35 mm in Riffles from Pebble Count Results (RDG and USFS 2003 data) and Comparison to Target Values

Water Body	Surveyor	Reach	Rosgen Stream Type	Feature	% Fines < 6.4 mm	Target	Departure from Target	Target Comparison
Crow Creek	LNF	**R1, WF XS2**	C4b	riffle	**26**	<15	**+11**	**Above Target**
Cooper Creek	LNF	R2, XS1, (FS R1)	B3c	riffle	8	<15	-7	Meets Target
Cooper Creek	LNF	R2, XS2, (FS R1)	B3c	riffle	4	<15	-11	Meets Target
Cooper Creek	LNF	**R3, (FS R2)**	C4/D4	riffle	**20**	<15	**+5**	**Above Target**
Cooper Creek	LNF	**R4, (FS R3)**	C4/B	riffle	**26**	<15	**+11**	**Above Target**

4.2.1.2 Percent Surface Fines < 6.35 mm in Pool Tails and Riffles (grid toss or equivalent)

Primary Sediment Target:
Less than 10% surface fines less than 6.35 mm in riffles and pools based on 49-point grid toss method or equivalent grid procedure.

Rationale:
Development of this target is another important criterion for evaluating whether or not excess sediment loading indicates an impact from “siltation” or excess fine sediment. The target values are based on the reference indicators developed in **Appendix G**.

Applicability Considerations:
Not meeting this target suggests a fine sediment impact to aquatic life and possibly cold water fish. Where the target value is not met, the stream is potentially impaired. The targets help with impairment or use support determinations in areas where McNeil Core data is lacking to evaluate substrate fines in fish spawning areas. The grid toss target can also apply in areas where pebble count data are lacking.

Where large sets of data are available, the median value can be used for comparison to the target value with caution. Individual reach areas where the target is not met may still require additional investigation to ensure that important spawning habitat or large reaches do not have significant beneficial use impacts.

Existing Conditions and Departure Analysis:
Results of percent surface fines < 6.35 mm in riffles based on grid toss data indicate that percent surface fines in riffles of mainstem Prospect Creek generally meet the target **(Table 4-3)** with the exception of one site in Reach 5. Results from tributary sites are variable. All sites in Clear Creek meet the target. In Dry Creek, both sites in Reach 3 on the mainstem do not meet the target as do one site in each of the East and West Forks of Dry Creek. All but one site in Wilkes Creek meet the target. In Cooper Creek, sites in Reaches 1 and 3 do not meet the target.

Table 4-3. Percent Surface Fines <6.35 mm in Riffles and Pool Tails Measured According to the 49-point Grid Toss Method (USFS 2003 data) and Comparison to Target Values

Water Body	Surveyor	Reach	Rosgen Stream Type	Feature	Median Grid-Toss (% <6.35 mm)	Target	Departure from Target	Target Comparison
Main Stem	LNF	R5, XS1, (FS R4)	C	riffle	2	<10	-8	Meets Target
Main Stem	LNF	**R5, XS2, (FS R4)**	C	riffle	**27**	<10	**17**	**Above Target**
Main Stem	LNF	R5, XS2, (FS R4)	C	pool	6	<10	-4	Meets Target
Main Stem	LNF	R5, (FS R3)	C	riffle	4	<10	-6	Meets Target
Main Stem	LNF	R5, (FS R3)	C	pool	2	<10	-8	Meets Target
Main Stem	LNF	R6, (FS R1)	B	riffle	2	<10	-8	Meets Target
Main Stem	LNF	R6, (FS R1)	B	pool	4	<10	-6	Meets Target
Clear Creek	LNF	R6	C	riffle	4	<10	-6	Meets Target
Clear Creek	LNF	R8	C	riffle	4	<10	-6	Meets Target
Clear Creek	LNF	R8	C	pool	0	<10	-10	Meets Target
Dry Creek	LNF	**R3**	C4	riffle	**12**	<10	**2**	**Above Target**
Dry Creek	LNF	**R3**	C4	pool	**61**	<10	**51**	**Above Target**
Dry Creek	LNF	R5, EF	C4	riffle	4	<10	-6	Meets Target
Dry Creek	LNF	**R5, EF**	C4	pool	**18**	<10	**8**	**Above Target**
Dry Creek	LNF	R5, WF	B4	riffle	2	<10	-8	Meets Target
Dry Creek	LNF	**R5, WF**	B4	pool	**16**	<10	**6**	**Above Target**
Wilkes Creek	LNF	R2, XS1	C4	riffle	8	<10	-2	Meets Target
Wilkes Creek	LNF	**R2, XS1**	C4	pool	**16**	<10	**6**	**Above Target**
Wilkes Creek	LNF	R2, XS2	C4	riffle	2	<10	-8	Meets Target
Wilkes Creek	LNF	R2, XS2	C4	pool	8	<10	-2	Meets Target
Crow Creek	LNF	R2, XS1	C3/4	riffle	6	<10	-4	Meets Target
Crow Creek	LNF	R2, XS1	C3/4	pool	2	<10	-8	Meets Target
Crow Creek	LNF	R2, XS2	C3/4	riffle	8	<10	-2	Meets Target
Crow Creek	LNF	R1, EF, XS1	C4b	riffle	4	<10	-6	Meets Target
Crow Creek	LNF	**R1, EF**	C4b	pool	**43**	<10	**33**	**Above Target**
Crow Creek	LNF	**R1, EF, XS2**	C4b	riffle	**14**	<10	**4**	**Above Target**
Crow Creek	LNF	R1, WF XS1	C4b	riffle	6	<10	-4	Meets Target
Crow Creek	LNF	R1, WF	C4b	pool	6	<10	-4	Meets Target
Crow Creek	LNF	R1, WF XS2	C4b	riffle	8	<10	-2	Meets Target
Cooper Creek	LNF	**R1**	F3	pool	**33**	<10	**23**	**Above Target**
Cooper Creek	LNF	R2, XS1	B3c	riffle	4	<10	-6	Meets Target
Cooper Creek	LNF	R2, XS2	B3c	riffle	2	<10	-8	Meets Target
Cooper Creek	LNF	R3	C4/D4	riffle	0	<10	-10	Meets Target
Cooper Creek	LNF	**R3**	C4/D4	pool	**14**	<10	**4**	**Above Target**
Cooper Creek	LNF	R4	C4/B	riffle	10	<10	0	Meets Target

4.2.1.3 Percent Substrate Fines < 6.35 mm in Pool Tails (McNeil Core)

Primary Sediment Target:
Less than 28% surface fines less than 6.35 mm in pool tailouts based on McNeil Cores.

Rationale:
Development of this target is one of the important criteria for evaluating whether or not excess fine sediment loading indicates a "siltation" type of impairment cause. Elevated levels of fine sediment in pool tail areas where fish spawning can occur will reduce fry emergence, therefore impairing cold-water fish. The target values are based on the reference development in **Appendix G.**

McNeil Core values that fall below 15%, which is the low end of the reference range, could be an indicator of another type of problem such as a degrading stream reach. If values this low occur, further investigation may be warranted.

Applicability Considerations:
This target can be applied based on yearly average results from a given stream reach or spawning segment. Where sampling is routinely performed, the target can instead be applied to an average value from three subsequent years of sampling.

This target (< 28% substrate fines) should only be applied in areas where bull trout or cutthroat trout spawning occurs or has the potential to occur under full support conditions. Not meeting this target alone represents a potential impairment from excess fine sediment if the upper end of the value is exceeded. If the lower end is exceeded, the stream could be impaired due to habitat alterations and additional study should be done to ensure proper pool values in the impacted range and to ensure that spawning locations are not being lost.

Core sampling tends to focus on potential impacts to bull trout spawning success. Equivalent core sampling targets that can provide a surrogate for core substrate fines also apply to cutthroat trout spawning areas.

Existing Conditions and Departure Analysis:
McNeil Core data were not available for the Prospect Creek watershed however this method is recommended as part of the monitoring and implementation strategy described later in this document.

4.2.1.4 Pool Frequency

Primary Sediment Target:
For B and C stream types, greater than 26 pools per mile for mainstem Prospect Creek and greater than 47 pools per mile for tributaries.

Rationale:
Pool frequency (pools/mile) is an important physical habitat parameter. Pools provide critical habitat for cold-water fish and are linked to the storage, deposition, and sorting of sediment

within the channel. This target is directly linked to the habitat alterations and to excess sediment loading conditions associated with bed load and larger size material contributing to aggradation, pool filling and/or interfering with pool formation. Loss of pools from excess sediment supply results in a direct reduction in fish habitat quantity and quality. The target values are based on the reference development in **Appendix G.**

Decreased pool frequency is the result of aggradation and pool filling which displaces in-stream water from the once deep pools that can provide refuge for fish, especially at low flow conditions. When streams aggrade and pools fill, in-stream water spreads across wide and shallow riffles which provide little habitat, and which under low flow conditions may dry up completely, providing no habitat.

Applicability Considerations:
Not meeting the target in the applicable reaches suggests potential sediment impact to cold-water fish.

Pool frequency targets may be supplemented and/or replaced by additional pool reference values or additional analysis based on measures such as residual pool depth or residual pool volume. Development of new pool targets could require a similar reference analysis as developed **Appendix G**.

Existing Conditions and Departure Analysis:
Based on counting the number of pool in sample segments of Prospect mainstem Reaches 2 through 4, Reaches 2, 3 and 4 of Prospect mainstem do not meet the pool frequency target of 26 pools per mile. Departure values are 33% or more below the target level. These results impact to mainstem Prospect Creek from either sediment or habitat alterations.

Based on pool counts from longitudinal profile surveys in Prospect mainstem Reaches 5 and 6, the pool target is satisfied by 124 and 248%. In the tributaries, conditions satisfy the low end of the pool target in Clear Creek Reach 8 and Dry Creek Reach 3. Other tributary reaches do not meet the minimum pool target of 47 pools per mile. Tributaries below target levels include Clear Creek Reaches 1 and 3, which are below the minimum pool target by 38 and 70% respectively, Crow Creek Reaches 1 and 2, which are below the minimum pool target by 25 and 62% respectively, Cooper Creek Reaches 1 and 3 which are below the minimum pool target by 30 and 61% respectively, and Dry Creek Reach 1 which is below the minimum pool target by 50%. These results indicate impairment conditions from sediment and/or habitat alterations in Clear, Crow and Cooper Creeks.

Table 4-4. Pool Frequency (Number of Pools per Unit Length) Based on Field Counts within Sample Segments (RDG 2004 data, unpublished) and Comparison to Target Values

Water Body	Surveyor	Reach	Rosgen Stream Type	Width*	Pool Frequency (pools /mile)	Pool Frequency Target (pools /mile)	Departure	Target Comparison
Mainstem	RDG	**R2, XS1**	D4	211.4	**17**	26	**-9**	**Below Target**
Mainstem	RDG	**R2, XS2**	D4/C4	102.1	**10**	26	**-16**	**Below Target**
Mainstem	RDG	**R2, XS3**	C4	87.5	**12**	26	**-14**	**Below Target**
Mainstem	**RDG**	**2**			**14**	26	**-12**	**Below Target**
Mainstem	RDG	**R3, XS1**	C3	61.7	**4**	26	**-22**	**Below Target**
Mainstem	RDG	**R3, XS2**	D4	179.9	**9**	26	**-17**	**Below Target**
Mainstem	RDG	**R3, XS3**	D4	104.4	**13**	26	**-13**	**Below Target**
Mainstem	**RDG**	**3**			**9**	26	**-17**	**Below Target**
Mainstem	RDG	**R4, XS1**	D4	118.0	**4**	26	**-22**	**Below Target**
Mainstem	RDG	**R4, XS2**	D3	81.7	**13**	26	**-13**	**Below Target**
Mainstem	RDG	**R4, XS3**	D4b	83.1	**13**	26	**-13**	**Below Target**
Mainstem	**RDG**	**4**			**9**	26	**-17**	**Below Target**
***Bankfull width or mean bankfull width from multiple riffle cross sections.**								

Table 4-5. Pool Frequency (Number of Pools per Unit Length) Based on Pools Measured in Longitudinal Profile Survey of Channel Thalweg (RDG 2004 data, unpublished) and Comparison to Target Values

Water Body	Surveyor	Reach	Rosgen Stream Type	Width*	Pool Frequency (pools/mile)	Pool Frequency Target (pools/mile)	Departure	Target Comparison
Mainstem	LNF	R5 (FS R3 &R4)	C	37.1	91	26	+65	Meets Target
Mainstem	LNF	R6 (FS R1)	B	32.1	58	26	+32	Meets Target
Clear	RDG	R3	C4	38.8	29	47	-18	Below Target
Clear	RDG	R1	C4	31.9	14	47	-33	Below Target
Clear	LNF	R8 (FS R 2b)	C	20.9	77	47	+30	Meets Target
Crow	RDG	R2	C4	29	35	47	-12	Below Target
Crow	RDG	R1	C4	26	18	47	-29	Below Target
Cooper	RDG	R3	C4/D4	21.7	33	47	-14	Below Target
Cooper	RDG	R1	C/F	29	18	47	-29	Below Target
Dry	RDG	R3	C4	20.8	47	47	0	Meets Target
Dry	RDG	R1	C4	27.7	23.5	47	-24	Below Target

4.2.1.5 Width-to-Depth Ratio

Supporting Sediment Target:
For B and C stream types, less than 30 for Prospect Creek mainstem and less than 20 for tributaries.

Rationale:
Width-to-depth (w/d) ratio is an important indicator of proper channel function. Width-to-depth ratio is normally measured as bankfull width to average bankfull depth at riffle cross sections. The target values are based on the reference development in **Appendix G**.

This target is directly linked to potential habitat alterations and is linked to excess sediment loading conditions. An excessive width-to-depth ratio can be the result of accelerated bank erosion and can decrease a stream's sediment transport capacity resulting in aggradation and pool filling. Excessive w/d can also lead to increased temperatures that can have negative impacts on aquatic life in Grave Creek or downstream waters.

Decreasing the width-to-depth ratio will concentrate flow into a narrower channel. Therefore, it will probably take less flow to meet a wetted perimeter type goal in a narrower, deeper channel than in the existing over-widened channel.

Applicability Considerations:
Not meeting this target implies potential impairment to cold-water fish. Excessive w/d values are a major indicator of sediment transport problems that can and likely are contributing to aggradation and pool filling. Furthermore, high w/d ratios are likely related to potential temperature impacts discussed below.

Existing Conditions and Departure Analysis:
In general, sites on Prospect Creek mainstem do not meet the w/d target. Exceptions include one site in each of Reaches 1 through 3, two of three sites in Reach 5, and the site in Reach 6 which meet the target. In Clear Creek, four of seven sites do not meet the w/d target. W/d results for sites in Dry Creek are variable. On the mainstem of Dry Creek, Reaches 1 and 3 do not meet the target as do the lower reaches in both East and West Fork Dry Creeks. The upper reaches of the East and West Forks of Dry Creek meet the target. All sites in Wilkes Creek meet the w/d target and all but one site in Reach 2 of Crow Creek meet the target. In Cooper Creek, half of the sites meet the target.

Table 4-6. Bankfull Width, Width to Depth Ratio (Ratio of Bankfull Width to Bankfull Mean Depth at Cross Sections (RDG and USFS 2003 data) and Comparison to Target Values

Water Body	Surveyors	Reach	Rosgen Stream Type	Width (ft)	W/D Ratio	Feature	Width-to-Depth Target	Departure	Target Comparison
Main Stem	RDG	R1, 1	B3c/F3	77.6	31.9	riffle	<30	+1.9	Above Target
Main Stem	RDG	R1, XS2	B2-3c/F2-3	51.3	11.5	step/ pool	<30	-18.5	Meets Target
Main Stem	RDG	**R2, XS1**	D4	211.4	**225.3**	riffle	<30	**+195.3**	**Above Target**
Main Stem	RDG	R2, XS2	D4/C4	102.1	29.0	pool/ braid	<30	-1.0	Meets Target
Main Stem	RDG	**R2, XS3**	C4	87.5	**36.2**	riffle	<30	**+6.2**	**Above Target**
Main Stem	RDG	**"Ref" C, XS1**	Ref C4	114.8	**102.1**	riffle	<30	**+72.1**	**Above Target**
Main Stem	RDG	**"Ref" C, XS2**	Ref C4	68.6	**70.5**	riffle	<30	**+40.5**	**Above Target**
Main Stem	RDG	**R3, XS1**	C3	61.7	**30.4**	riffle	<30	**+0.4**	**Above Target**
Main Stem	RDG	**R3, XS2**	D4	179.9	**319.1**	braid	<30	**+289.1**	**Above Target**
Main Stem	RDG	**R3, XS3**	D4	104.4	**212.4**	braid	<30	**+182.4**	**Above Target**
Main Stem	RDG	R3, XS4	C4	49.6	27.1	riffle/ Ref C	<30	-2.9	Meets Target
Main Stem	RDG	**R4, XS1**	D4	118.0	**99.4**	braid	<30	**+69.4**	**Above Target**
Main Stem	RDG	**R4, XS2**	D3	81.7	**108.7**	braid	<30	**+78.7**	**Above Target**
Main Stem	RDG	**R4, XS3**	D4b	83.1	**103.8**	riffle	<30	**+73.8**	**Above Target**
Main Stem	LNF	R5, XS1, (FS R4)	C	37.3	21.7	riffle	<30	-8.3	Meets Target
Main Stem	LNF	**R5, XS2, (FS R4)**	C	40.9	**31.4**	riffle	<30	**+1.4**	**Above Target**
Main Stem	LNF	R5, (FS R3)	C	33.2	14.6	riffle	<30	-15.4	Meets Target
Main Stem	LNF	R6, (FS R1)	B	32.1	13.8	riffle	<30	-16.2	Meets Target
Clear Creek	RDG	**R1, XS1**	C4	29.1	**73.2**	riffle	<20	**+53.2**	**Above Target**
Clear Creek	RDG	**R1, XS2**	C4	34.6	**34.8**	riffle	<20	**+14.8**	**Above Target**
Clear Creek	RDG	R2	B4c/F4b	26.5	13.7	step/ pool	<20	-6.3	Meets Target

Table 4-6. Bankfull Width, Width to Depth Ratio (Ratio of Bankfull Width to Bankfull Mean Depth at Cross Sections (RDG and USFS 2003 data) and Comparison to Target Values

Water Body	Surveyors	Reach	Rosgen Stream Type	Width (ft)	W/D Ratio	Feature	Width-to-Depth Target	Departure	Target Comparison
Clear Creek	RDG	**R3**	C4	38.8	**32.3**	riffle	<20	**+12.3**	**Above Target**
Clear Creek	RDG	**R4**	D4	353.2	**441.0**	braid	<20	**+421.0**	**Above Target**
Clear Creek	LNF	**R6, (FS R2)**	C	36.8	**25.8**	riffle	<20	**+5.8**	**Above Target**
Clear Creek	LNF	R8, (FS R2b)	C	20.9	13.6	riffle	<20	-6.4	Meets Target
Dry Creek	RDG	**R1**	C4	27.7	**23.6**	riffle	<20	**+3.6**	**Above Target**
Dry Creek	RDG	R2	A3	20.0	7.4	riffle	<20	-12.6	Meets Target
Dry Creek	RDG	**R3**	C4	27.5	**39.8**	riffle	<20	**+19.8**	**Above Target**
Dry Creek	RDG	**R4, WF**	D4b	71.3	**229.7**	braid	<20	**+209.7**	**Above Target**
Dry Creek	RDG	**R4, EF**	D4b	67.0	**107.2**	braid	<20	**+87.2**	**Above Target**
Dry Creek	RDG	R5, WF	Ref B4	14.2	11.7	riffle	<20	-8.4	Meets Target
Dry Creek	LNF	R3	C4	20.8	12.6	riffle	<20	-7.4	Meets Target
Dry Creek	LNF	R5, EF	C4	14.7	12.7	riffle	<20	-7.3	Meets Target
Dry Creek	LNF	R5, WF	B4	13.0	7.0	riffle	<20	-13.0	Meets Target
Wilkes Creek	RDG	R1	B4c	13.4	10.5	riffle	<20	-9.5	Meets Target
Wilkes Creek	RDG	R2	C4	14.6	17.0	riffle	<20	-3.1	Meets Target
Wilkes Creek	RDG	R3	B4c	17.6	16.5	riffle	<20	-3.5	Meets Target
Wilkes Creek	LNF	R2, XS1	C4	17.8	17.8	riffle	<20	-2.2	Meets Target
Wilkes Creek	LNF	R2, XS2	C4	19.1	12.0	riffle	<20	-8.0	Meets Target
Crow Creek	LNF	**R2, XS1**	C3/4	28.9	**20.5**	riffle	<20	**+0.5**	**Above Target**
Crow Creek	LNF	R2, XS2	C3/4	26.2	17.2	riffle	<20	-2.8	Meets Target
Crow Creek	LNF	R1, EF, XS1	C4b	19.3	16.7	riffle	<20	-3.3	Meets Target
Crow Creek	LNF	R1, EF, XS2	C4b	19.8	15.6	riffle	<20	-4.4	Meets Target
Crow Creek	LNF	R1, WF XS1	C4b	17.7	12.0	riffle	<20	-8.0	Meets Target
Crow Creek	LNF	R1, WF XS2	C4b	17.9	12.2	riffle	<20	-7.8	Meets Target
Cooper Creek	LNF	R2, XS1	B3c	27.5	16.7	riffle	<20	-3.3	Meets Target
Cooper Creek	LNF	**R2, XS2**	B3c	30.5	**21.3**	riffle	<20	**+1.3**	**Above Target**
Cooper Creek	LNF	**R3**	C4/D4	73.1	**104.9**	riffle	<20	**+84.9**	**Above Target**
Cooper Creek	LNF	R4	C4/B	21.7	9.3	riffle	<20	-10.7	Meets Target

4.2.1.6 Sinuosity

Supporting Sediment Target:
For B and C stream types 1.2 to 1.4.

Rationale:
This indicator is linked to habitat alterations and is linked to excess sediment loading conditions. Reduced sinuosity causes increased sheer stress contributing to accelerated bank erosion, increased width-to-depth ratio and reduced sediment transport capacity. As a result, there is an excess sediment supply, aggradation and pool filling/loss of pools. The sinuosity range is based on the reference development in **Appendix G**.

Not meeting the low end of the range implies continued sediment problems.

Applicability Considerations:
Exceeding the high end should not be a problem. Values below 1.2 suggest an undesirable and over-straightened reach.

Existing Conditions and Departure Analysis:
In general, the sinuosity target is not met in Prospect Creek mainstem. All sites in all reaches are below the low end of the target range with a few exceptions. Exceptions include the “reference” site found in Reach 2, one site in Reach 3, and one site in Reach 5. Most sites in Clear Creek also do not meet the sinuosity target. All sites in the mainstem of Dry Creek meet the sinuosity target although sites in East and West Fork of Dry Creek do not meet the sinuosity target. Three out of four sites in Wilkes Creek meet the target while site in Crow Creek do not. In Cooper Creek, four out of seven sites meet the sinuosity target.

Table 4-7. Sinuosity (Ratio of Channel Length to Valley Length) Interpreted from 2000 Air Photos for Approximately 10 Bankfull Widths Upstream and 10 Bankfull Widths Downstream of 2003 Cross Section Locations (RDG and USFS 2003 data) and Comparison to Target Values

Water Body	Surveyor	Reach	Rosgen Stream Type	Existing Sinuosity	Sinuosity Indicator Range	Departure from 1.2	Departure from 1.4	Comparison To Low End of Indicator Range
Main Stem	RDG	**R1, XS1**	B3c/F3	**1.02**	1.2 - 1.4	**-0.18**	**-0.38**	**Below Target**
Main Stem	RDG	**R1, XS2**	B2-3c/F2-3	**1.02**	1.2 - 1.4	**-0.18**	**-0.38**	**Below Target**
Main Stem	RDG	**R2, XS1**	D4	**1.06**	1.2 - 1.4	**-0.14**	**-0.34**	**Below Target**
Main Stem	RDG	**R2, XS2**	D4/C4	**1.04**	1.2 - 1.4	**-0.16**	**-0.36**	**Below Target**
Main Stem	RDG	**R2, XS3**	C4	**1.15**	1.2 - 1.4	**-0.05**	**-0.25**	**Below Target**
Main Stem	RDG	"Ref" C,	Ref	1.7	1.2 - 1.4	+0.5	+0.3	Meets Target

Table 4-7. Sinuosity (Ratio of Channel Length to Valley Length) Interpreted from 2000 Air Photos for Approximately 10 Bankfull Widths Upstream and 10 Bankfull Widths Downstream of 2003 Cross Section Locations (RDG and USFS 2003 data) and Comparison to Target Values

Water Body	Surveyor	Reach	Rosgen Stream Type	Existing Sinuosity	Sinuosity Indicator Range	Departure from 1.2	Departure from 1.4	Comparison To Low End of Indicator Range
		XS1	C4					
Main Stem	RDG	**R3, XS1**	C3	**1.12**	1.2 - 1.4	**-0.08**	**-0.28**	**Below Target**
Main Stem	RDG	**R3, XS2**	D4	**1.09**	1.2 - 1.4	**-0.11**	**-0.31**	**Below Target**
Main Stem	RDG	**R3, XS3**	D4	**1.05**	1.2 - 1.4	**-0.15**	**-0.35**	**Below Target**
Main Stem	RDG	R3, XS4	C4	1.46	1.2 - 1.4	+0.26	+0.06	Meets Target
Main Stem	RDG	**R4, XS1**	D4	**1.03**	1.2 - 1.4	**-0.17**	**-0.37**	**Below Target**
Main Stem	RDG	**R4, XS2**	D3	**1.08**	1.2 - 1.4	**-0.12**	**-0.32**	**Below Target**
Main Stem	RDG	**R4, XS3**	D4b	**1.15**	1.2 - 1.4	**-0.05**	**-0.25**	**Below Target**
Main Stem	LNF	**R5, (FS R3)**	C	**1.1**	1.2 - 1.4	**-0.1**	**-0.3**	**Below Target**
Main Stem	LNF	R5, (FS R4)	C	1.36	1.2 - 1.4	+0.16	-0.04	Meets Target
Main Stem	LNF	**R6**	B	**1.04**	1.2 - 1.4	**-0.16**	**-0.36**	**Below Target**
Clear Creek	RDG	**R1**	C4	**1.14**	1.2 - 1.4	**-0.06**	**-0.26**	**Below Target**
Clear Creek	RDG	**R2**	B4c/F 4b	**1.09**	1.2 - 1.4	**-0.11**	**-0.31**	**Below Target**
Clear Creek	RDG	R3	C4	1.5	1.2 - 1.4	+0.3	+0.1	Meets Target
Clear Creek	RDG	**R4**	D4	**1.05**	1.2 - 1.4	**-0.15**	**-0.35**	**Below Target**
Clear Creek	LNF	**R1**	C4/D 4	**1.12**	1.2 - 1.4	**-0.08**	**-0.28**	**Below Target**
Clear Creek	LNF	**R2**	C4/D 4	**1.12**	1.2 - 1.4	**-0.08**	**-0.28**	**Below Target**
Clear Creek	LNF	R3	C4/D 4	1.24	1.2 - 1.4	+0.04	-0.16	Meets Target
Clear Creek	LNF	R4	C4/D 4	1.32	1.2 - 1.4	+0.12	-0.08	Meets Target
Clear Creek	LNF	**R5**	F3	**1.12**	1.2 - 1.4	**-0.08**	**-0.28**	**Below Target**
Clear Creek	LNF	R6	C3/D 4	1.3	1.2 - 1.4	+0.1	-0.1	Meets Target
Dry Creek	RDG	R1, XS1	C4	1.4	1.2 - 1.4	+0.2	0	Meets Target
Dry Creek	RDG	R1, XS1	B4c	1.4	1.2 - 1.4	+0.2	0	Meets Target
Dry Creek	RDG	R3, XS1	C4	1.7	1.2 - 1.4	+0.5	+0.3	Meets Target
Dry Creek	RDG	R3, XS1	C4b	1.7	1.2 - 1.4	+0.5	+0.3	Meets Target
Dry Creek	RDG	R3, XS1	Ref C	1.7	1.2 - 1.4	+0.5	+0.3	Meets Target
Dry Creek	RDG	R4, WF, XS1	D4b	1.5	1.2 - 1.4	+0.3	+0.1	Meets Target
Dry Creek	RDG	**R4, EF, XS1**	D4b	**1.0**	1.2 - 1.4	**-0.2**	**-0.4**	**Below Target**

Table 4-7. Sinuosity (Ratio of Channel Length to Valley Length) Interpreted from 2000 Air Photos for Approximately 10 Bankfull Widths Upstream and 10 Bankfull Widths Downstream of 2003 Cross Section Locations (RDG and USFS 2003 data) and Comparison to Target Values

Water Body	Surveyor	Reach	Rosgen Stream Type	Existing Sinuosity	Sinuosity Indicator Range	Departure from 1.2	Departure from 1.4	Comparison To Low End of Indicator Range
Dry Creek	RDG	**R5, WF, XS1**	Ref B4	**1.03**	1.2 - 1.4	**-0.17**	**-0.37**	**Below Target**
Dry Creek	LNF	**R3**	C4	**1.13**	1.2 - 1.4	**-0.07**	**-0.27**	**Below Target**
Dry Creek	LNF	R5, EF	C4	1.2	1.2 - 1.4	0	-0.2	Meets Target
Dry Creek	LNF	**R5, WF**	B4	**1.02**	1.2 - 1.4	**-0.18**	**-0.38**	**Below Target**
Wilkes Creek	RDG	**R1**	B4c	**1.07**	1.2 - 1.4	**-0.13**	**-0.33**	**Below Target**
Wilkes Creek	RDG	R2	C4	1.5	1.2 - 1.4	+0.3	+0.1	Meets Target
Wilkes Creek	RDG	R3	B4c	1.33	1.2 - 1.4	+0.13	-0.07	Meets Target
Wilkes Creek	LNF	R2 (FS R1)	C4	1.23	1.2 - 1.4	+0.03	-0.17	Meets Target
Crow Creek	LNF	**R1**	C3/4	**1.14**	1.2 - 1.4	**-0.06**	**-0.26**	**Below Target**
Crow Creek	LNF	**R2**	C3/4	**1.14**	1.2 - 1.4	**-0.06**	**-0.26**	**Below Target**
Cooper Creek	LNF	**R1**	F3	**1.0**	1.2 - 1.4	**-0.2**	**-0.4**	**Below Target**
Cooper Creek	LNF	R2	B3c	1.31	1.2 - 1.4	+0.11	-0.09	Meets Target
Cooper Creek	LNF	R3	C4/D4	1.23	1.2 - 1.4	+0.03	-0.17	Meets Target
Cooper Creek	LNF	R4	C4/B	1.26	1.2 - 1.4	+0.06	-0.14	Meets Target
Cooper Creek	LNF	**R5**	B4/C	**1.15**	1.2 - 1.4	**-0.05**	**-0.25**	**Below Target**
Cooper Creek	LNF	**R6**	C4/B	**1.09**	1.2 - 1.4	**-0.11**	**-0.31**	**Below Target**
Cooper Creek	LNF	R7	B4 to C4	1.22	1.2 - 1.4	+0.02	-0.18	Meets Target
-- Sinuosity difficult or impossible to measure due to dense vegetation cover and/or to stream size relative to photo scale.								

4.2.1.7 Riffle Stability Index

Supporting Sediment Target:
For B and C stream types, 40 to 70.

Rationale:
The RSI target values are based on the reference development in **Appendix G**. The "Riffle Stability Index" (RSI) developed by Kappesser (2002) provides a means of evaluating sediment loading. High RSI values (>70%) suggest excess sediment loading, low RSI values (<40%) suggest low sediment loading and/or channel scour. RSI values between 40 and 70% suggest dynamic equilibrium.

Applicability Considerations:
RSI analysis should be based on pebble counts and bar count data from the same year or same stream flow conditions.

Existing Conditions and Departure Analysis:
All mainstem Prospect Creek sites exceed the upper end of the target range suggesting excess sediment loading. In Clear Creek, of the four sites evaluated, two in lower Clear Creek exceed the upper end of the target range suggesting excess sediment loading, one in middle Clear Creek is within the target range, suggesting equilibrium, and one in upper Clear Creek is below the lower end of the target range, suggesting scour or lack of sediment loading. Three of the four sites evaluated in Dry Creek are above the target range indicating excess sediment loading. All sites evaluated in the remaining tributaries (Wilkes, Crow and Cooper Creeks) were also above the upper end of the target range indicating excess sediment loading.

Table 4-8. Riffle Stability Index (Percent Cumulative Finer-Than Value of Riffle Pebble Count Results Corresponding to the Geometric Mean of the 30 Largest Mobile Particles on the Depositional Bar Nearest the Riffle Pebble Count Location) (RDG and USFS 2003 data) and Comparison to Target Values

Water Body	Surveyor	Reach	Rosgen Stream Type	Feature	Target	RSI	Target Comparison
Main Stem	RDG	**R2, XS1**	D4	riffle	40-70	**97**	**Above Target**
Main Stem	RDG	**R2, XS2**	D4/C4	riffle	40-70	**98**	**Above Target**
Main Stem	RDG	**Ref C, XS1**	Ref C4	riffle	40-70	**96**	**Above Target**
Main Stem	RDG	**"Ref" C, XS2**	Ref C4	riffle	40-70	**98**	**Above Target**
Main Stem	RDG	**R3, XS2**	D4	braid	40-70	**97**	**Above Target**
Main Stem	RDG	**R3, XS3**	D4	braid	40-70	**90**	**Above Target**
Main Stem	RDG	**R4, XS1**	D4	braid	40-70	**85**	**Above Target**
Main Stem	RDG	**R4, XS2**	D3	braid	40-70	**89**	**Above Target**
Main Stem	RDG	**R4, XS3**	D4b	riffle	40-70	**77**	**Above Target**
Main Stem	LNF	**R5, (FS R3)**	C	riffle	40-70	**78**	**Above Target**
Clear Creek	RDG	**R3**	C4	riffle	40-70	**97**	**Above Target**
Clear Creek	RDG	**R4**	D4	braid	40-70	**98**	**Above Target**
Clear Creek	LNF	R6, (FS R2)	C	riffle	40-70	65	Meets Target
Clear Creek	LNF	**R8, (FS R2b)**	C	riffle	40-70	**24**	**Below Target**
Dry Creek	RDG	**R1**	C4	riffle	40-70	**80**	**Above Target**
Dry Creek	RDG	**R3**	C4	riffle	40-70	**93**	**Above Target**
Dry Creek	LNF	R3	C4	riffle	40-70	68	Meets Target
Dry Creek	LNF	**EF**	C4	riffle	40-70	**92**	**Above Target**
Wilkes Creek	RDG	**R2**	C4	riffle	40-70	**81**	**Above Target**
Wilkes Creek	LNF	**R2, XS2**	C4	riffle	40-70	**77**	**Above Target**
Crow Creek	LNF	**R1, WF XS1**	C4b	riffle	40-70	**71**	**Above Target**
Cooper Creek	LNF	**R3, (FS R2)**	C4/D4	riffle	40-70	**98**	**Above Target**
Cooper Creek	LNF	**R4, (FS R3)**	C4/B	riffle	40-70	**77**	**Above Target**

4.2.1.8 Large Woody Debris

Supporting Sediment Target: Large woody debris objectives are defined in **Table 4-9**.

Table 4-9. Summary of LWD Reference Values for Prospect Creek Watershed

Stream Type and Bankfull Width (Stream Order)	LWD / Mile Indicator Range	LWD and/or Aggregates per Mile Indicator Range
B & C streams 10' - 20' (generally 2nd and 3rd order)	163 - 371	228 - 519
B & C streams 20' - 35' (generally 3rd and 4th order streams)	112 - 443	157 - 620
B and C streams 36' - 50', (generally 4th or 5th order streams)	104 - 210	146 - 294

Rationale:
The large woody debris (LWD) target values are based on the reference development in **Appendix G**. Large woody debris frequency (total pieces of LWD/mile) is a parameter used as a physical habitat indicator. Large woody debris (LWD) is considered an important habitat feature for cold-water fish, particularly for bull trout. In many streams, LWD can play an important role in forming pools or creating pools with greater residual pool depths. LWD can also help establish streambed stability, dissipate energy, and directly influence sediment storage (Rosgen, 1996). A lack of woody debris (values less than the low end of the indicator range in **Table 4-9**) can be linked to potential sediment impairment since LWD helps establish streambed stability, dissipates energy, and directly influences sediment storage (Rosgen, 1996).

Applicability Considerations:
Not meeting the LWD use support objective, along with other indications of habitat problems, can support an "other habitat alterations" impairment cause. Impairment determinations linked to LWD should generally be limited to smaller stream sizes, primarily those less than 35 feet bankfull width. It can be applied to larger C reaches where LWD retention is more likely. Statistical distributions of the individual stream or watershed data can be used to help evaluate overall LWD conditions relative to reference. Future monitoring of the streams of interest and any reference streams should include identification of any linkages between LWD and increased refugia for fish and linkages between LWD and pool formation.

Factors that can influence a stream's ability to retain LWD within the active channel will be a function of stream size, stream gradient, and the overall size of the LWD piece (both diameter and length) relative to stream size and energy. Higher numbers of LWD are typically associated with narrower and lower order streams.

Existing Conditions and Departure Analysis:
Using the results for LWD greater than 16' length, mainstem Prospect Creek Reaches 3 and 5 do not meet the LWD target. All reaches of Clear Creek, Dry, and Cooper creeks do not meet the LWD target. In Crow Creek, East Fork Crow Creek reach is the only reach to meet the LWD target.

Table 4-10. Large Woody Debris Concentration (Amount of Large Woody Debris per Unit Length) (RDG 2004 data) and Comparison to Target Values

Water Body	Surveyor	Reach	Rosgen Stream Type	LWD* Indicator Range	Total LWD (pcs/mile) >16ft	Departure from Low End of Indicator Range (>16ft)	Comparison to Indicator Range (>16ft)	Total LWD (pcs/mile) >5ft	Departure from Low End of Indicator Range (>5ft)	Comparison to Indicator Range (> 5ft)
Main Stem	RDG	R2	D4/C4	146-294	155	9	Meets Target	213	67	Meets Target
Main Stem	RDG	**R3**	D4/C4	146-294	117	**-29**	**Below Target**	139	**-7**	**Below Target**
Main Stem	RDG	R4	D4/3	146-294	173	27	Meets Target	232	86	Meets Target
Main Stem	LNF	**R5, (FS R3)**	C	146-294	119	**-27**	**Below Target**	172	26	Meets Target
Clear Creek	RDG	**R1**	C4	146-294	129	**-17**	**Below Target**	164	18	Meets Target
Clear Creek	RDG	**R2**	B4c/F4b	146-294	53	**-93**	**Below Target**	79	**-67**	**Below Target**
Clear Creek	RDG	**R3**	C4	146-294	88	**-58**	**Below Target**	168	22	Meets Target
Clear Creek	RDG	**R4**	D4	146-294	128	**-18**	**Below Target**	189	43	Meets Target
Clear Creek	LNF	**R1**	C4/D4	146-294	59	**-87**	**Below Target**	164	18	Meets Target
Clear Creek	LNF	**R2**	C4/D4	146-294	44	**-102**	**Below Target**	88	**-58**	**Below Target**
Dry Creek	RDG	**R1**	C4	157-620	151	**-6**	**Below Target**	211	54	Meets Target
Dry Creek	RDG	**R2**	A3	157-620	70	**-87**	**Below Target**	188	31	Meets Target
Dry Creek	RDG	**R3**	C4	157-620	136	**-21**	**Below Target**	174	17	Meets Target
Dry Creek	RDG	**R4, WF**	D4b/B4	228-519	70	**-158**	**Below Target**	158	**-70**	**Below Target**
Dry Creek	RDG	**R4, EF**	D4b/C4	228-519	67	**-161**	**Below Target**	120	**-108**	**Below Target**
Crow Creek	LNF	**R1**	C3/4	157-620	99	**-58**	**Below Target**	148	**-9**	**Below Target**
Crow Creek	LNF	**R2**	C3/4	157-620	147	**-10**	**Below Target**	153	**-4**	**Below Target**
Crow Creek	LNF	R1, EF	C4b	228-519	264	36	Meets Target	340	36	Meets Target
Crow Creek	LNF	**R1, WF**	C4b	228-519	170	**-58**	**Below Target**	182	**-46**	**Below Target**
Cooper Creek	LNF	**R1**	F3	157-620	141	**-16**	**Below Target**	246	89	Meets Target
Cooper Creek	LNF	**R2**	B3c	157-620	97	**-60**	**Below Target**	123	**-34**	**Below Target**
Cooper Creek	LNF	**R3**	C4/D4	157-620	60	**-97**	**Below Target**	99	**-58**	**Below Target**
Cooper Creek	LNF	**R4**	C4/B	157-620	114	**-43**	**Below Target**	128	**-29**	**Below Target**
Cooper Creek	LNF	**R5**	B4/C	157-620	62	**-95**	**Below Target**	79	**-78**	**Below Target**
Cooper Creek	LNF	**R6**	C4/B	157-620	18	**-139**	**Below Target**	18	**-139**	**Below Target**
Cooper Creek	LNF	**R7**	B4 to C4	228-519	62	**-166**	**Below Target**	70	**-158**	**Below Target**

* In-channel and recruitable, singles and aggregates.

4.2.1.9 Riparian Vegetation

Supporting Sediment Target:
For streams with active channel width < 75 feet:
% Canopy Cover using densiometer measurement > 75%
For streams with active channel width > 75 feet:
% Canopy Cover using densiometer measurement > 60%

Rationale:
The ability for riparian vegetation to reduce the affects of erosion on a stream is dependent upon the type of vegetation and the degree of stabilization (related to vegetative maturity and depth of roots) that the vegetation provides. The amount of large woody debris that is suitable for impacting morphology and creating fish habitat is also directly linked to the maturity and composition of the adjacent riparian community.
The Prospect Creek watershed has a long history of activities that have affected the riparian vegetation, and in many places along the stream corridor these affects are still evident. The target values for mature tree % is based on the results of an field assessment which found that in areas of least disturbance that demonstrate a healthy riparian community, a canopy density of approximately 75% can be expected. These areas typically occur on active channels less than 75 feet. Based on this information, a conservative estimation for those reaches with active channel widths greater than 75 feet is proposed to contain 60% riparian canopy density. In the Prospect Creek watershed, areas with active channel widths greater than 75 feet typically have greater variation in stream morphology and have a greater amount of influencing factors (roads, powerlines, private property) that reduce the potential for the riparian community to achieve a 75% mature pine forest composition.

The target values for % canopy are based on the comparison between aerial photo interpretations and field derived densiometer measurements for riparian areas dominated by mature pine forest, and a conservative estimation for potential for areas currently not dominated by this vegetative community type are based on those results.

Applicability Considerations:
Not meeting these targets indicates a potential lack of bank stability which may have a direct impact on a number of factors influencing water quality and the ability to support cold water fish and aquatic life. A lack of riparian vegetation and associated bank instability may lead to an increase in sediment from eroding banks. Increases in sediment often lead to a decrease in pools as they fill in with the additional depositional load. As banks erode and pools fill in, a stream will often increase in width and decrease in depth, altering and limiting the available holding habitat for trout. When streams widen and shallow, they are often quicker to show the affects of thermal radiation (heat), especially if shade that would be provided by riparian vegetation is not available. Furthermore, an intact riparian corridor along the stream provides input of large woody debris that is influential in creating pools and holding or refuge habitat for fish.

Existing Conditions and Departure Analysis:
All the sites pertain to the mainstem of Prospect Creek. A review of each reach shows 36% of sites in Reach 2 exceed the target canopy by at least 10%, and an exceedence of at least 10% in Reaches 3, 4, and 5 by 34%, 70% and 68% respectively (**Table 4-11**).

Information presented in **Appendix C** describes some inaccuracies between percent canopy derived from aerial photo analysis and field verification using a densitometer. In general for field verified sites, percent canopy cover for sites with left bank/right bank vegetation composition other than mature trees was considerably lower than aerial photo analysis results. This suggests departure from targets may actually be greater than that what is represented through the aerial photo analysis.

Table 4-11. Riparian Canopy Analysis and Comparison to Target Values

Reach	Site	# of Threads	Total Active Channel Width (feet)	Left Bank Vegetation	Right Bank Vegetation	Percent Canopy	Percent Canopy Target	Departure From Target
2	1	2	150	shrub/small trees	shrub/small trees	46	60	14
2	2	2	220	mature trees	shrub/small trees	47	60	13
2	3	1	100	shrub/small trees	shrub/small trees	39	60	21
2	4	1	120	bare ground/grass/shrub	bare ground/grass	27	60	33
2	5	1	210	bare ground/grass/shrub	shrub/small trees	30	60	30
2	6	2	150	mature trees	shrub/small trees	68	60	
2	7	1	130	shrub/small trees	shrub/small trees	74	60	
2	8	2	150	shrub/small trees	shrub/small trees	74	60	
2	9	1	90	bare ground/grass	mature trees	71	60	
2	10	3	300	shrub/small trees	shrub/small trees	41	60	19
2	11	1	150	shrub/small trees	shrub/small trees	52	60	8
2	12	1	150	bare ground/grass	shrub/small trees	58	60	2
2	13	2	180	bare ground/grass	shrub/small trees	64	60	
2	14	3	210	shrub/small trees	grass/shrub	44	60	16
2	15	1	165	grass/shrub/small trees	shrub/small trees	39	60	21
2	16	1	100	bare ground/grass	shrub/small trees	68	60	
2	17	3	300	bare ground/grass/shrub	shrub/small trees	61	60	
2	18	1	135	mature trees	mature trees	77	60	
2	19	1	150	mature trees	shrub/small trees	74	60	
2	20	1	150	shrub/small trees	mature trees	68	60	
2	21	2	150	shrub/small trees	shrub/small trees	81	60	
2	22	2	170	shrub/small trees	bare ground/grass	52	60	8
2	23	3	120	shrub/small trees	mature trees	64	60	
2	24	4	350	bare ground/grass/shrub	mature trees	55	60	5
2	25	2	225	shrub	shrub/small trees	63	60	
2	26	2	350	shrub	shrub/small trees	49	60	11
2	27	1	120	shrub/small trees	mature trees	49	60	11
2	28	1	210	bare ground/grass/shrub	mature trees	37	60	23
2	29	3	200	shrub	shrub/small trees	51	60	9
2	30	2	375	shrub/small trees	shrub/small trees	60	60	0

Table 4-11. Riparian Canopy Analysis and Comparison to Target Values

Reach	Site	# of Threads	Total Active Channel Width (feet)	Left Bank Vegetation	Right Bank Vegetation	Percent Canopy	Percent Canopy Target	Departure From Target
2	31	1	225	small trees	shrub/mature trees	68	60	
3	1	1	120	shrub/small trees	mature trees	77	60	
3	2	2	300	grass/shrub/small trees	shrub/small trees	49	60	11
3	3	1	150	shrub/small trees	mature trees	72	60	
3	4	1	120	bare ground/grass/shrub	shrub/small trees	54	60	6
3	5	1	180	grass/shrub/small trees	shrub/small trees	61	60	
3	6	3	90	shrub/small trees	shrub/small trees	68	60	
3	7	1	100	grass/shrub/small trees	mature trees	21	60	39
3	8	2	300	grass/shrub/small trees	shrub/small trees	59	60	1
3	9	2	160	shrub/small trees	mature trees	54	60	6
3	10	1	225	bare ground/grass	bare ground/ rass/shrub/mature trees	56	60	4
3	11	2	120	shrub/small trees	shrub/small trees	76	60	
3	12	2	190	shrub/small trees	mature trees	72	60	
3	13	2	375	bare ground/grass/shrub	shrub/small trees	35	60	25
3	14	1	95	shrub/small trees	mature trees	75	60	
3	15	2	135	geadss/shrub/small trees	mature trees	66	60	
3	16	3	110	shrub/small trees	mature trees	71	60	
3	17	2	120	bare ground/grass/shrub	mature trees	43	60	17
3	18	2	150	mature trees	shrub/mature trees	74	60	
3	19	1	225	grass/mature trees	grass/shrub/small trees	58	60	2
3	20	2	225	bare ground/grass/shrub	bare/shrub/small trees	64	60	
3	21	1	100	bare ground/grass	mature trees	39	60	21
3	22	1	200	bare ground/grass/shrub	shrub/small trees	38	60	22
3	23	1	120	grass/shrub/small trees	small/mature trees	31	60	29
3	24	1	95	bare ground/grass	shrub/small trees	45	60	15
3	25	1	210	shrub/small trees	shrub/small trees	58	60	2
3	26	2	190	shrub/small trees	grass/shrub/small trees	56	60	4
3	27	1	150	shrub/small trees	shrub/small trees	65	60	
3	28	1	120	bare ground/grass/shrub	grass/shrub/small trees	64	60	
3	29	1	100	bare ground/grass/shrub	grass/shrub/small trees	44	60	16
3	30	2	75	shrub/small trees	shrub/mature trees	71	75	4
3	31	3	65	bare ground/grass/shrub	shrub/small trees	42	75	33
3	32	1	150	grass/shrub/small trees	shrub/small trees	47	60	13
4	1	2	250	bare ground/grass	mature trees	25	60	35
4	2	3	180	bare ground/grass/shrub	grass/mature trees	32	60	28
4	3	3	250	shrub/small trees	grass/shrub/small trees	34	60	26
4	4	1	180	shrub/mature trees	shrub/shrub/small trees	46	60	14
4	5	2	195	shrub/small trees	grass/shrub	26	60	34
4	6	3	225	grass/shrub/small trees	grass/shrub/small trees	18	60	42
4	7	3	300		bare/grass/shrub	17	60	43
4	8	2	300	bare ground/grass/shrub	bare/grass/shrub	14	60	46
4	9	2	300	mature trees	grass/shrub/small trees	25	60	35
4	10	2	270	shrub/mature trees	grass/shrub	31	60	29

Table 4-11. Riparian Canopy Analysis and Comparison to Target Values

Reach	Site	# of Threads	Total Active Channel Width (feet)	Left Bank Vegetation	Right Bank Vegetation	Percent Canopy	Percent Canopy Target	Departure From Target
4	11	2	200	mature trees	grass/shrub	25	60	35
4	12	1	225	grass/shrub/small trees	bare/grass/shrub	28	60	32
4	13	1	120	shrub/small trees	shrub/small trees	46	60	14
4	14	2	70	bare ground/grass/shrub	shrub/mature trees	44	75	31
4	15	1	90	grass/shrub/small trees	grass/shrub/small trees	39	60	21
4	16	1	105	mature trees	shrub/small trees	41	60	19
4	17	1	120	mature trees	mature trees	54	60	6
4	18	2	135	mature trees	mature trees	39	60	21
4	19	2	115	mature trees	mature trees	52	60	8
4	20	1	115	mature trees	mature trees	61	60	
4	21	1	135	mature trees	shrub/small trees	34	60	26
4	22	1	90	mature trees	grass/mature trees	61	60	
4	23	2	75	mature trees	mature trees	90	75	
4	24	1	65	mature trees	mature trees	90	75	
4	25	1	75	mature trees	mature trees	71	75	4
4	26	2	90	mature trees	grass/mature trees	63	60	
4	27	2	110	bare ground/grass/shrub	grass/shrub/small trees	32	60	28
4	28	2	105	mature trees	mature trees	76	60	
4	29	2	150	shrub/small trees	mature trees	49	60	11
4	30	2	190	shrub/small trees	shrub/small trees	40	60	20
5	1	1	40	mature trees	mature trees	59	75	16
5	2	2	80	grass/shrub	shrub/mature trees	53	60	7
5	3	1	60	mature trees	mature trees	56	75	19
5	4	1	50	mature trees	shrub/mature trees	53	75	22
5	5	1	75	mature trees	shrub/small trees	50	75	25
5	6	2	50	mature trees	mature trees	57	75	18
5	7	1	40	bare ground/grass/mature trees	mature trees	43	75	32
5	8	2	40	mature trees	shrub/small trees	50	75	25
5	9	1	45	mature trees	mature trees	61	75	14
5	10	2	90	mature trees	grass/shrubs/mature trees	56	60	4
5	11	1	75	shrub/small trees	grass/shrub/small trees	16	75	59
5	12	1	75	shrub/small trees	shrub/small trees	31	75	44
5	13	2	100	shrub/small trees	shrub/small trees	53	60	7
5	14	1	90	mature trees	grass/shrub/small trees	53	60	7
5	15	1	90	bare ground/grass/shrub	shrub/small trees	30	60	30
5	16	1	30	grass/small trees	mature trees	57	75	18
5	17	1	30	mature trees	mature trees	87	75	
5	18	1	20	mature trees	mature trees	87	75	
5	19	1	25	shrub/mature trees	mature trees	74	75	1
5	20	1	45	grass/mature trees	mature trees	78	75	
5	21	1	20	bare ground/grass	mature trees	50	75	25
5	22	1	20	grass/shrub/small trees	mature trees	50	75	25
5	23	1	20	grass/shrub/small trees	mature trees	64	75	11
5	24	1	55	bare ground/grass	shrub/small trees	43	75	32

Table 4-11. Riparian Canopy Analysis and Comparison to Target Values

Reach	Site	# of Threads	Total Active Channel Width (feet)	Left Bank Vegetation	Right Bank Vegetation	Percent Canopy	Percent Canopy Target	Departure From Target
5	25	1	30	bare ground/grass/shrub	shrub/mature trees	50	75	25
5	26	1	30	bare ground/grass/shrub	shrub/small trees	50	75	25
5	27	2	45	shrub/small trees	mature trees	43	75	32
5	28	1	25	grass/shrub/small trees	mature trees	57	75	18
5	29	1	20	grass/mature trees	mature trees	71	75	4
5	30	1	25	shrub/small trees	mature trees	64	75	11
5	31	1	20	mature trees	mature trees	71	75	4

4.2.1.10 Macroinvertebrate Populations

Supporting Sediment Target:

Mountain MMI >63

RIVPACS O/E value: $0.8 \leq X \geq 1.2$

Rationale:

The DEQ employs two tools when evaluating the health of the aquatic invertebrate community in a stream of concern. A multimetric index (MMI) and the River Invertebrate Prediction and Classification System (RIVPACS). The threshold values or targets for these tools provide a direct indication of beneficial use support for aquatic life.

The MMIs are organized based upon the ecoregions of Montana. Ecoregions are mapped areas based upon climate, geophysical, and general vegetation characteristics. Three MMIs are used to represent the various ecoregions of Montana: Mountain, Low Valley, and Plains. The Prospect Creek watershed requires the Mountain MMI. Both the MMI and RIVPACS models use reference data that capture the characteristics of healthy aquatic invertebrate communities, and compare the results of a given sampling event to the threshold values for each tool.

The MMI score is based upon the average of individual metrics scores. The metric scores measure predictable attributes of benthic macroinvertebrate communities to make inferences regarding aquatic life condition when pollution or pollutants affect stream systems and instream biota.

The RIVPACS model compares the taxa that are expected at a site under a variety of environmental conditions with the actual taxa that were found when the site was sampled. The RIVPACS model provides a single number to infer the health of the macroinvertebrate community. If the output value of the RIVPACS model falls between a range of 0.8-1.2 the stream is considered fully supporting aquatic invertebrates.

Used in combination, if both tools impairment determinations are in agreement, the results suggest strong evidence that a waterbody is either supporting or non-supporting for aquatic invertebrates, depending on if the threshold values are met. If the impairment determinations of the two tools do not agree, inferences can still be made based on the departure from the threshold value, and a more detailed look at the taxa that exist at the site.

Applicability Considerations:
Not meeting these targets represents a potential impairment to aquatic life. Data collection should ideally include riffle samples from two to four typical cross sections along each stream segment being evaluated. Sampling should also be performed in areas where target conditions indicate a possible impairment (such as high percent fines in riffle areas).

Existing Conditions and Departure Analysis:
Both the MMI and RIVPACS models have only recently been developed and applied to data available to the DEQ. Clear Creek, Cooper Creek, and Dry Creek are the only streams in the Prospect watershed that have been analyzed using the new tools. At some locations, Dry Creek had values well below the thresholds for both tools, while all locations on Clear Creek and Cooper Creek meet the thresholds necessary to show conditions that support a healthy aquatic macroinvertebrate community.

The use of the new aquatic macroinvertebrate tools, and the associated target values are to be used for all subsequent aquatic macroinvertebrate data collected throughout the Prospect Creek watershed for analysis of aquatic life support in the Prospect TPA.

Table 4-12. Aquatic Macroinvertebrate Summary Statistics for Prospect Creek Watershed

Waterbody Name	Station ID	MMI Score	RIVPACS score
Clear Creek	C13CLERC01	86.54407312	1.071121
Clear Creek	C13CLERC02	77.45756019	0.886019
Cooper	SHB-471	70.56321054	1.011798
Cooper Creek	PIBO_0137	71.28927717	0.943565
Cooper Creek	PIBO_0137	73.74690079	0.943565
Dry Creek	BKK047	86.30642824	0.692118
Dry Creek	C13DRYC01	35.94884465	0.63469
Dry Creek	PIBO_0138	67.48776595	0.760349
Dry Creek	PIBO_0138	64.99256248	0.760349
Dry Creek	C13DRYC02	14.3991808	---

Green indicates the target values have been met, yellow indicates the target values have not been met but are within a close range of the target value, and red indicates probable impairment to the aquatic macroinvertebrate community.

4.3 Water Quality Status Summary

Primary Targets must be satisfied under most conditions to support the achievement of the beneficial uses. Meeting primary targets will likely suggest a fully supporting determination, however, a stream can have impacted water quality despite meeting some primary targets when the entire suite of supporting targets and other factors linked to pollutant source loading

ultimately show a significant negative impact to the resource. Similarly, the achievement of one primary target parameter, in the absence of any additional data linked to other primary or supporting targets, does not preclude that the stream is in optimal condition, rather, it is strongly advised that a determination be withheld until sampling could occur to address at least a few other of the parameters of concern, and strengthen the argument either for or against.

4.3.1 Prospect Creek Mainstem

Departure analysis results suggest that aquatic life mainstem Prospect Creek is not likely impacted by excessive fine sediment loading as indicated by Wolman pebble counts and grid toss data. Although, grid toss data were only available in the upper two reaches of mainstem Prospect Creek.

Pool frequency data demonstrates a lack of pools in mainstem Prospect Creek suggesting habitat impairment for cold-water fish likely related to excess sediment loading and habitat alterations. Low pool frequency values are influenced by low LWD numbers.

Width-to-depth ratio results in mainstem Prospect Creek also generally indicate impairment to cold-water fish and aquatic life due to excess sediment loading and habitat alterations. These results are linked to overall lack of pools and are indicative of high stream temperatures.

Generally low sinuosity values on mainstem Prospect Creek also suggest impairments to cold-water fish and aquatic life due to habitat alterations and sediment loading.

RSI results indicate excess sediment loading to all evaluated reaches of mainstem Prospect Creek. These results indicate impairment to cold-water fish and aquatic life as a result of excess sediment and habitat alterations. High RSI values are likely related to low pool frequency and high w/d values.

Mainstem Prospect Creek is generally deficient in LWD suggesting impairment to cold-water fish as a result of habitat alterations. Where LWD targets are met, they are met minimally. Low LWD is also likely a contributing factor to low pool frequency.

Of the 13 sub-reaches inventoried as part of the canopy density study, only two sections in Reach 5 met the canopy density target, and all sections with an active channel width >75’ were well below the 60% target at an average of 24%.

Macroinvertbrate communities were not able to be analyzed using the new DEQ metrics at the time of this report.

Overall, indicators suggest that mainstem Prospect Creek aquatic life and cold-water fish is impacted as a result of excessive sediment loading (coarse sediment), habitat alterations and elevated stream temperatures.

4.3.2 Clear Creek

Generally, percent surface fines targets in Clear Creek are met indicating no impairment to aquatic life or cold water fish from excess fine sediment.

Pool frequency in Clear Creek is below target levels in two of three reaches assessed. This suggests habitat impairment for cold-water fish related to sediment loading and habitat alterations. Low pool frequency is linked to high w/d, low sinuosity, and low LWD.

Width-to-depth ratios in Clear Creek do not meet target values in most reaches indicating impairment to cold water fish from excess sediment loading and habitat alterations. These results are linked to low pool frequency and low sinuosity.

Clear Creek generally has low sinuosity indicating impairment to cold-water fish and aquatic life as a result of excess sediment loading and habitat alterations. Low sinuosity is linked to low pool frequency and high width-to-depth values.

RSI results in Clear Creek, where available, are variable. Excess sediment loading is indicated in the lower reaches, conditions meet target levels in the middle reach, and in the upper, headwater reach, RSI results suggest channel scour. Based on these results, it is likely that cold water fish and aquatic life are impaired in the lower reaches as a result of sediment loading. High RSI values in the lower reaches are likely related to low pool frequency and high w/d values. The Upper Reach is a higher gradient reach in a headwater location with low sediment supply. While RSI results suggest channel scour and possible impairment, the nature of the reach may otherwise explain conditions.

Clear Creek is deficient in LWD in all reaches indicating impairment to cold-water fish as a result of habitat alterations. Low LWD values is likely related to low pool frequency.

Clear Creek was not analyzed as part of the riparian canopy density study however future field efforts should be made to compare existing conditions to the targets.

The two sites on Clear Creek analyzed using the new macroinvertebrate tools indicate full support of the aquatic macroinvertebrate community.

Overall, indicators suggest cold-water fish in Clear Creek is impacted as a result of excessive sediment loading (coarse sediment) and habitat alterations.

4.3.3 Dry Creek

Excess percent surface fines in all riffles of Dry Creek (except the high gradient A reach) indicate an impact to aquatic life from excessive fine sediment loading. Where available, grid toss data also generally suggest impairment to aquatic life and cold-water fish from excess fine sediment.

Pool frequency results in Dry Creek are variable. Reach 3 meets the target, whereas pool frequency in Reach 1 is insufficient. This may indicate habitat impairment for cold-water fish in the lower part of the stream and is likely related to excess sediment loading, high w/d and low LWD numbers.

High width-to-depth ratios in Dry Creek (except for the high-gradient A reach and the upper reaches of the Forks) suggest impairment to cold-water fish and aquatic life due to excess sediment loading. These results are linked to lack of LWD and are indicative of high stream temperatures.

Dry Creek generally meets the sinuosity target. Low sinuosity in the lower reaches of both Forks is likely related to road and trail encroachment.

Of the Dry Creek sites evaluated for RSI, generally high RSI results indicate excess sediment loading. These results indicate impairment to cold-water fish and aquatic life as a result of excess sediment and are likely related to low pool frequency, low LWD and high w/d values.

LWD is deficient in all reaches of Dry Creek indicating impairment to cold-water fish as a result of habitat alterations.

Dry Creek was not analyzed as part of the riparian canopy density study however future field efforts should be made to compare existing conditions to the targets.

Of the four macroinvertebrate samples analyzed for Dry Creek, two samples had a large divergence from the target for both the MMI and RIVPACS, while the other two samples were meeting but close to the threshold for MMI and just under the threshold for the RIVPACS model.

Overall, indicators suggest that aquatic life and cold-water fish is impacted in Dry Creek as a result of excessive sediment loading and habitat alterations.

4.3.4 Wilkes Creek

Percent surface fines in riffles in reaches 2 and 3 of Wilkes Creek do not meet the target, although the values are only slightly above, with an average exceedence of 4%. The grid toss or equivalent method for determining percent fines in riffles and pool tails resulted in all sites meeting the target except for one site in Reach 2 which is only slightly above the target.

Width-to-depth ratio targets were met for all sampled sites in Wilkes Creek.

Of the reaches measured for sinuosity, the lowest most reach (Reach 1) is the only section below the target.

Only two sites, both in Reach 2 were evaluated for riffle stability. Both sites are above the high end of the target with values of 81 and 77 respectively. Values over 70 indicate excess sediment loading.

Wilkes Creek was not analyzed as part of the riparian canopy density study however future field efforts should be made to compare existing conditions to the targets.

Large woody debris, pool frequency, and macroinvertebrate communities were not sampled in the Wilkes Creek drainage but the majority of the information suggests that Wilkes Creek is in relatively good condition related to sediment.

4.3.5 Crow Creek

Of the six sites sampled for percent surface fines using the pebble count method, only one site is meeting the target. The grid toss method provides data showing most sites are in compliance with the target, although two sites in the East Fork Crow Creek are exceeding by 33% and 4% respectively.

Reaches 1 and 2 of the mainstem Crow Creek are the only locations investigated for pool frequency and are below the minimum pool target by 25% and 62%.

All sites inventoried are meeting the width to depth target with the exception of one site which was only above the target by .5.

Crow mainstem reaches 1 and 2 are slightly below the low end of the target for sinuosity. These values may be influenced by roads and infrastructure maintenance within the Crow Creel watershed.

One site on West Fork Crow Creek was evaluated for Riffle Stability and was just barely above the high end of the target with a value of 71. The target range for RSI is 40-70 with numbers on the high end or above indicating excess sediment loading.

East Fork Crow Creek is the only section in the Crow Creek watershed to meet the target for large woody debris.

Crow Creek was not analyzed as part of the riparian canopy density study however future field efforts should be made to compare existing conditions to the targets.
Crow Creek was not analyzed as part of the riparian canopy density study however future field efforts should be made to compare existing conditions to the targets.

Although limited, data does suggest that Crow Creek does have some impact to cold water fish and aquatic life from fine and course sediment, and habitat alterations. Percent fines were high in some instances, pool frequency low, with sinuosity slightly below the target as well. Large woody debris was lacking in all sections but the East Fork.

Further support can be made for impact from sediment by looking to the source assessment studies (**Section 5.0**) which show that Reach 2 of Crow Creek has an extremely high sediment load from bank erosion (518 tons/.1 mile/year) when compared to other sections of the Crow Creek watershed (38 tons/.1 mile/year). Likewise, surface erosion from roads using the XDrain

method indicates that Crow Creek is the largest contributor of sediment in the watershed from this source at 47.3 tons/year. This information indicates that Crow Creek should be targeted for additional assessment and restoration and implementation projects should be considered.

4.3.6 Cooper Creek

Of the eight reaches identified in Cooper Creek, only reaches 1,2,3, and 4 had data available to analyze percent surface fines. Using the Wolmann pebble count method, reaches 2, 3, and 4 were analyzed with only reach 2 meeting the target. With the grid toss method, sites 1 and 3 were exceeding the target with reach 1 being well above the target by 23%.

Pool frequency was only analyzed in reaches 1 and 3 but in both cases was well short of the target value by 30 and 61 respectively.

Of the four sites investigated for width to depth ratios, reach 3 is the only site in exceedence, however it is drastically above the desired width to depth value with a measurement of 105 in comparison to the target of 20.

Sinuosity was also below the target in some reaches with Reach 1 being the most beneath the target with a value of 1.0 compared to the target range of 1.2-1.4.

Using the Riffle Stability Index as an indicator of possible aggrading or degrading conditions, a target range of 40-70 is proposed, with numbers at the upper exceedence of the range indicating excess sediment loading, and numbers at the beneath the range suggesting channel scour and sediment poor system. Only two sites were measured in Cooper Creek but both were above the RSI target with values of 98 and 77.

All sites in the Cooper Creek drainage that were investigated did not meet the large woody debris target.

Cooper Creek was not analyzed as part of the riparian canopy density study however future field efforts should be made to compare existing conditions to the targets.

Three sites were analyzed using the new DEQ macroinvertebrate assessment tools and all three sites were determined to be fully supporting based on the results of these assessments.

Despite the macroinvertebrate tools which suggest that the macroinvertebrate community is currently being supported, a substantial amount of the data currently available for Cooper Creek indicates that there may be impacts from sediment (both fine and coarse) and that habitat important to cold water fish is lacking throughout much of the drainage as well. Efforts to further assess Cooper Creek and investigate restoration options should be considered

SECTION 5.0
SOURCE ASSESSMENT AND SEDIMENT QUANTIFICATION

Several different sediment models were used to evaluate average annual sediment loading from various sources identified in the Prospect Creek watershed. LoloSED, a watershed-based model, was used to estimate average annual natural background sediment loading. LoloSED was also used to model erosion and sediment delivery at the watershed scale from timber harvest. The XDRAIN model was used to examine site-specific sediment contribution from road surface erosion. Sediment from bank erosion was estimated using field data and the Bank Erosion Hazard Index (BEHI) (Rosgen, 2001). Finally, sediment contribution from traction sand application to County Highway 471 was approximated using known application rates and field-measured buffer characteristics. Potential average annual sediment loading from culvert failures was evaluated in a separate analysis presented in **Appendix H**.

Models simplify extremely complex physical systems and are developed from a limited database. Although specific quantitative values for sediment are generated from the models used in this analysis, it is important to note that the results are used as a tool in the interpretation of how real systems may respond. Therefore, the models' use is realistically limited to providing a means of comparison, not an absolute measure against verifiable standards.

5.1 LoloSED

The LoloSED computer model was used to analyze sediment production at the watershed scale. LoloSED was adapted from the WATSED model. WATSED is a sediment production model developed by USDA Forest Service Region One and others (USDA, 1991). LoloSED is a spatially based, GIS implementation of WATSED, and includes coefficients specific to resources on the Lolo National Forest. LoloSED uses GIS layers for soil and landform (LSI), topography (DEM), hydrology (streams), vegetation (TSMRS stands), transportation (roads), precipitation (average annual), and project specific layers.

5.1.1 Natural Background Loading from Hillslope Erosion

The Lolo National Forest's Land System Inventory (LSI) provides a natural hillslope sediment production coefficient for every land unit. Land units in the LSI, also known as LSI units or LSI's, were delineated based on soil, landform, and habitat type (USDA, 1988).

Natural sediment production from National Forest land in the Prospect Creek watershed was calculated by first overlaying the HUC 6 watersheds layer for the Prospect Creek with the LSI layer. A DEM (digital elevation model) was used to determine the average side slope and topographic position for each LSI unit in the Prospect Creek watershed. Hillslope and topographic position determine the sediment delivery ratio for each unit. The natural sediment production coefficients and delivery ratios were multiplied together to get a sediment yield value for each HUC 6.

Natural sediment production based on average annual precipitation was modeled for each HUC 6 tributary to the Prospect Creek . These results were then summarized for the Prospect Creek HUC 5 (**Table 5-1**), which represents the entire Prospect Creek watershed. HUC 6 watersheds and overall Prospect Creek HUC 5 watershed is illustrated in **Figure 5-1**. LoloSED- modeled annual, natural sediment production for the Prospect Creek HUC 5 is approximately 1010 tons/year. HUC 6 sediment production normalized by area shows the Cooper Creek watershed as most erosive, 8.4 tons/mi^2/year, and Lower Prospect Creek HUC 6 as least erosive, 4.4 tons/mi^2/year (**Table 5-1**). It should be noted that natural hillslope sediment production can be significantly increased as a result of fire events and is not accounted for in this analysis.

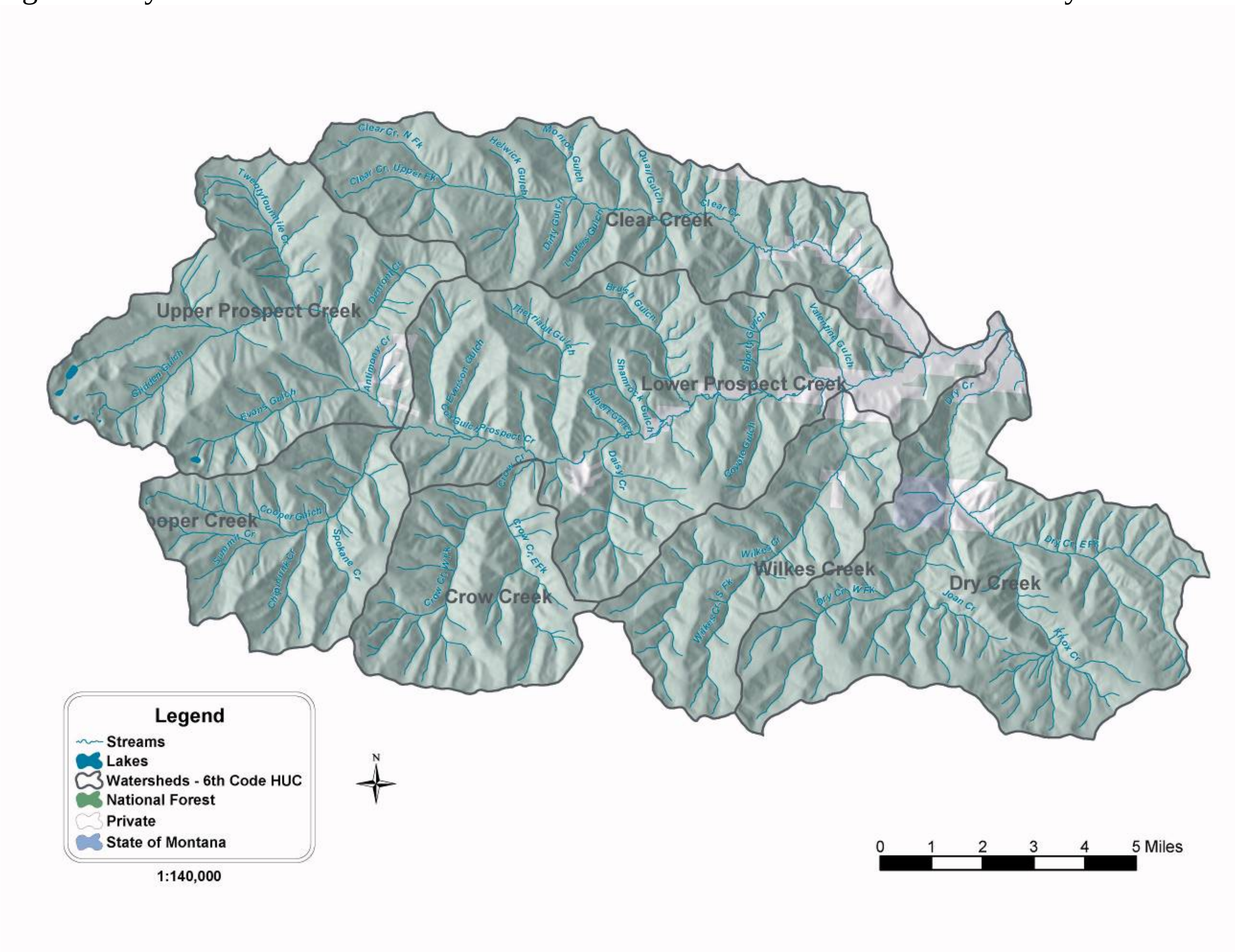


Figure 5-1. Prospect Creek Watershed Hydrology

Table 5-1. LoloSED Modeled Natural Sediment Production from Hillslope Erosion in the Prospect Creek Watershed

Watershed (6th code HUC)	Modeled Annual, Natural Sediment Production (tons/year)	Area (mi2)	Natural Sediment Production Normalized by area (tons/mi2/year)
Clear	147	28.6	5.1
Cooper	133	15.8	8.4
Crow	87	14.8	5.9
Dry	206	35.8	5.7
Lower Prospect	177	40.3	4.4
Upper Prospect	187	29.6	6.3
Wilkes	74	15.8	4.7
Prospect Creek (HUC 5 watershed)	**1011**	**180.7**	**5.6**

5.1.2 Sediment from Timber Harvest

In addition to natural sediment production and delivery, hillslope erosion sediment from harvest activity was also analyzed. Other sediment erosion impacts that could be linked to harvest activity, such as roads, are addressed later in this section. The LoloSED model was used to estimate current hillslope sediment production increases above natural due to timber harvest activities on record. ***This information is for National Forest Service land only.*** 94% of the Prospect Creek watershed is located within National Forest lands. The remaining 6% currently constitutes small subdivision type land use with impacts largely associated with stream side development (e.g. bank erosion), and not timber harvest. LoloSED was run in March 2004 to generate these estimates which are based on the information provided in the TSMRS (timber stand management recording system) for this date, and will not include sediment produced from harvest operations not included in TSMRS at that time.

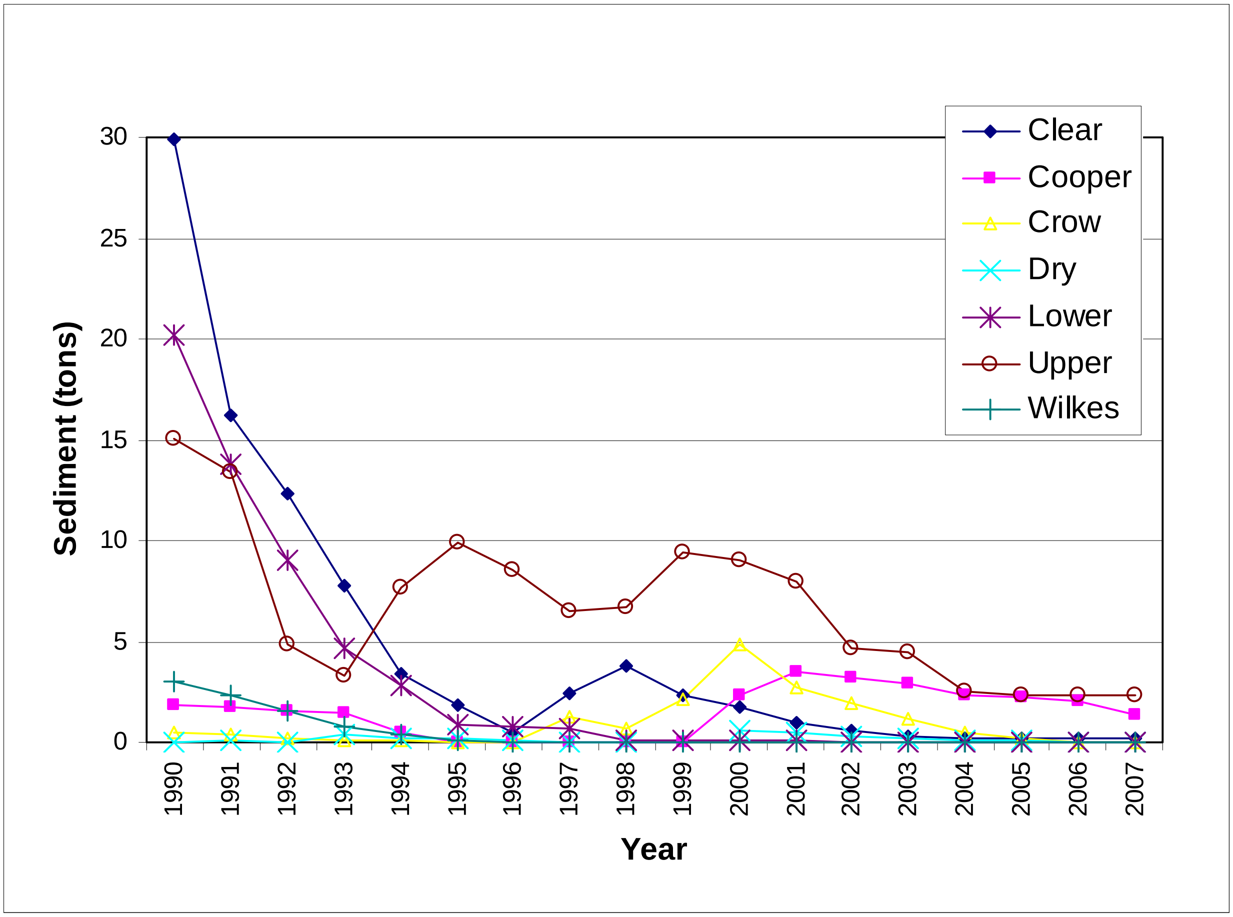


Figure 5-2. LoloSED-Modeled Average Annual Hillslope Erosion Sediment Load from TSMRS-Recorded Timber Harvest Activity on National Forest Land

For sediment production from timber harvest areas, production coefficients for the logging system used (tractor, skyline, or helicopter) were applied to the natural sediment production values discussed in the previous section. The production coefficients assume varying levels of sediment production and imply certain incorporated BMPs that affect the overall sediment load.

Based on model results for years 1990 - 2007, sediment production from timber harvest peaked in the early 1990's at approximately 70.5 tons above natural, and continued to decline until 1997 for all sub-watersheds except for Upper Prospect HUC 6. Increases in harvest-related sediment production occurred in 1995 and 1999, in Upper Prospect Creek, in 1998 in Clear Creek, in 2000 in Crow Creek and 2001 in Cooper Creek. After 2001, sediment from recorded harvest activities declined through the remainder of the analysis period. This analysis does not reflect activities which have occurred since March 2004, and those not recorded in the TSMRS database at the time of the analyses. Sediment projected for 2005-2007 reflects a static condition in harvest activity. Future harvest activities may increase sediment above the static condition. The current (2007) sediment load from timber harvest is derived from this analysis.

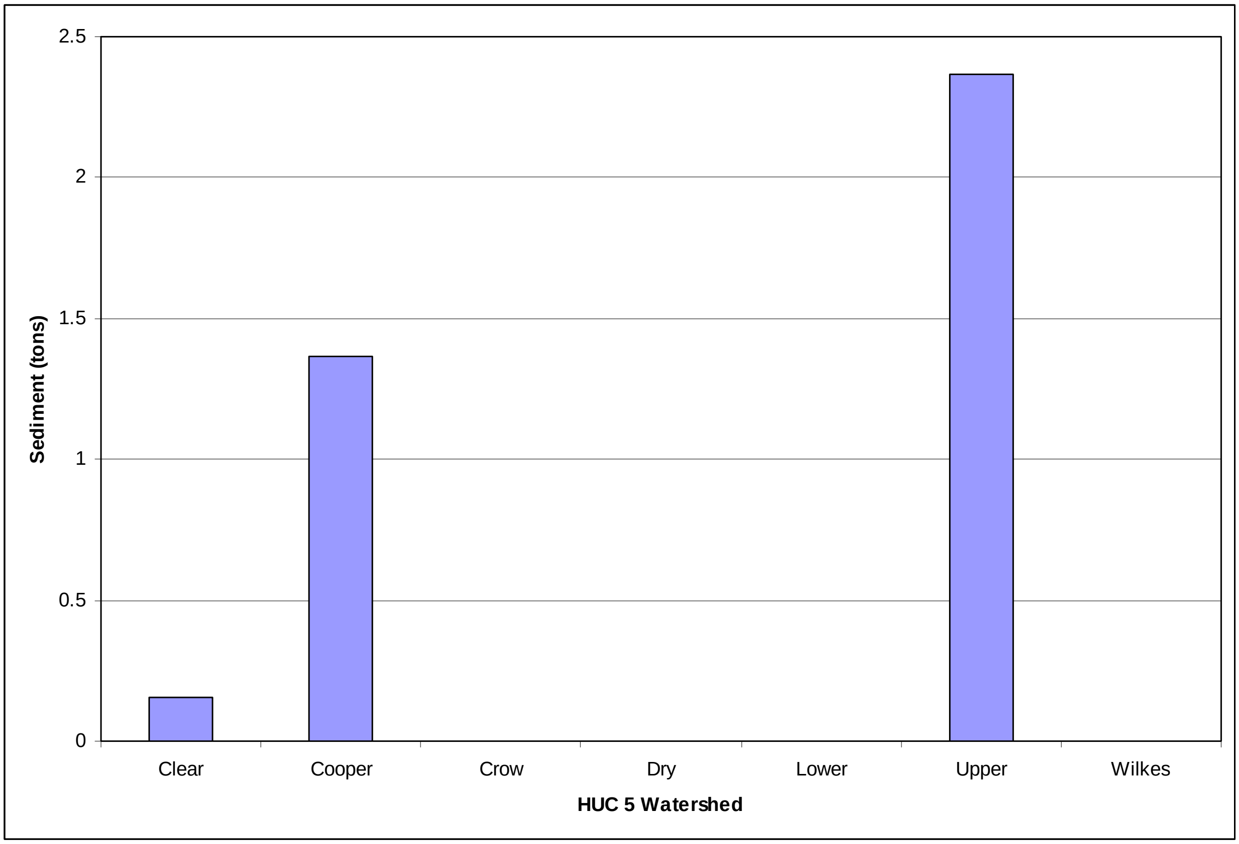


Figure 5-3. Projected 2007 Lolosed-Modeled Average Annual Sediment Load from TSMRS-Recorded Timber Harvest Activity on National Forest Land if No Harvest Activity

5.2 Sediment at Stream Crossings

5.2.1 XDRAIN Methods

Analysis of potential sediment input to stream crossings from roads was conducted using X-DRAIN 2.0 (Elliot et al., 1999). X-DRAIN 2.0 requires 5 input variables: climate station, soil type, buffer length, buffer gradient, and road width. From the X-DRAIN climate database, the climate data for Seeley Lake, MT most closely resembled climate data in Thompson Falls, MT, and was therefore used in the model runs for Prospect Creek. Soil types were determined based on the LSI unit corresponding to each crossing location.

The buffer length value used for all stream crossings was either 0 or 33 feet depending on field measurements. If the field-measured distance from the road to the stream at the crossing was closer to 0 than to 33 feet (e.g. 4 feet), then 0 was selected as the input variable. If the field-measured distance from the road to the stream at the crossing was closer to 33 feet than to 0 (e.g. 28 feet), then 33 was selected as the input variable. None of the field-measured buffer distances exceeded 33 feet.

If a buffer was present, buffer gradient used was 60%. Buffer gradients observed in the field were all 60% or greater. Road width varied from 10 to 27 feet. Based on these input variables, X-

DRAIN 2.0 generated an output matrix of annual sediment yield for variable road gradients (2, 4, 8, and 16%) and cross-drain spacing (30, 100, 200, 400, 800 feet). For each crossing, a sediment yield value was selected from the appropriate output matrix according to the field-measured drain spacing and road gradient.

Table 5-2. XDRAIN Variable Values Used to Evaluate Sediment Yield for Stream Crossings in the Prospect Creek Watershed

XDRAIN Variable	Value Used for Prospect Creek Crossings
Climate station	Seeley Lake, MT
Soil type	Varied by LSI
Buffer length	0 or 33 feet depending upon field data
Buffer gradient	60 %
Road width	Varies (10-27 feet)

Seventy-four Prospect Creek watershed crossings were evaluated for road sediment contribution using X-DRAIN 2.0. This sub-sample represents approximately 30% of the stream crossings in the Prospect Creek watershed. GIS analysis of road and stream intersections results in 307 crossings (**Appendix B**).

5.2.2 XDRAIN Results

Total sediment contribution from the XDRAIN analysis was summarized by HUC 6 (**Table 5-3**). Assuming the sub-sample is a representative sample of all the culverts in the Prospect Creek watershed, extrapolating the HUC 6 means of the 74-culvert sub-sample to the projected 307-culvert crossing population, total annual sediment contribution at stream crossings is 126.5 tons per year. The greatest contributions are from Clear, Crow and Lower Prospect Creek (**Figure 5-4**).

Table 5-3. XDRAIN-Calculated Sediment Load from Road Surface Erosion Contributed at Inventoried Stream Crossings and Extrapolated Sediment Load to Un-Inventoried Stream Crossings

	Inventoried Crossings					Extrapolation	
HUC 6	**Number of Inventoried Crossings**	**Min.**	**Mean**	**Max.**	**Sediment Yield (tons/year)**	**Number of Crossings in HUC 6 by GIS**	**Extrapolated* Sediment Yield (tons/year)**
Clear	19	0.02	0.42	2.79	7.94	76	31.7
Cooper	12	0.02	0.24	1.37	2.91	16	3.9
Crow	15	0.02	1.48	9.65	22.15	32	47.3
Dry	5	0.01	0.34	1.49	1.69	23	7.8
Lower Prospect	14	0.01	0.19	0.63	2.71	114	22.1
Upper Prospect	5	0.03	0.32	1.13	1.58	29	9.2
Wilkes	4	0.02	0.27	0.96	1.08	17	4.6
Total	**74**				**40.06**	**307**	**126.5**
*Mean sediment yield of inventoried crossings by HUC 6 multiplied by adjusted estimate of total number of crossings in HUC 6.							

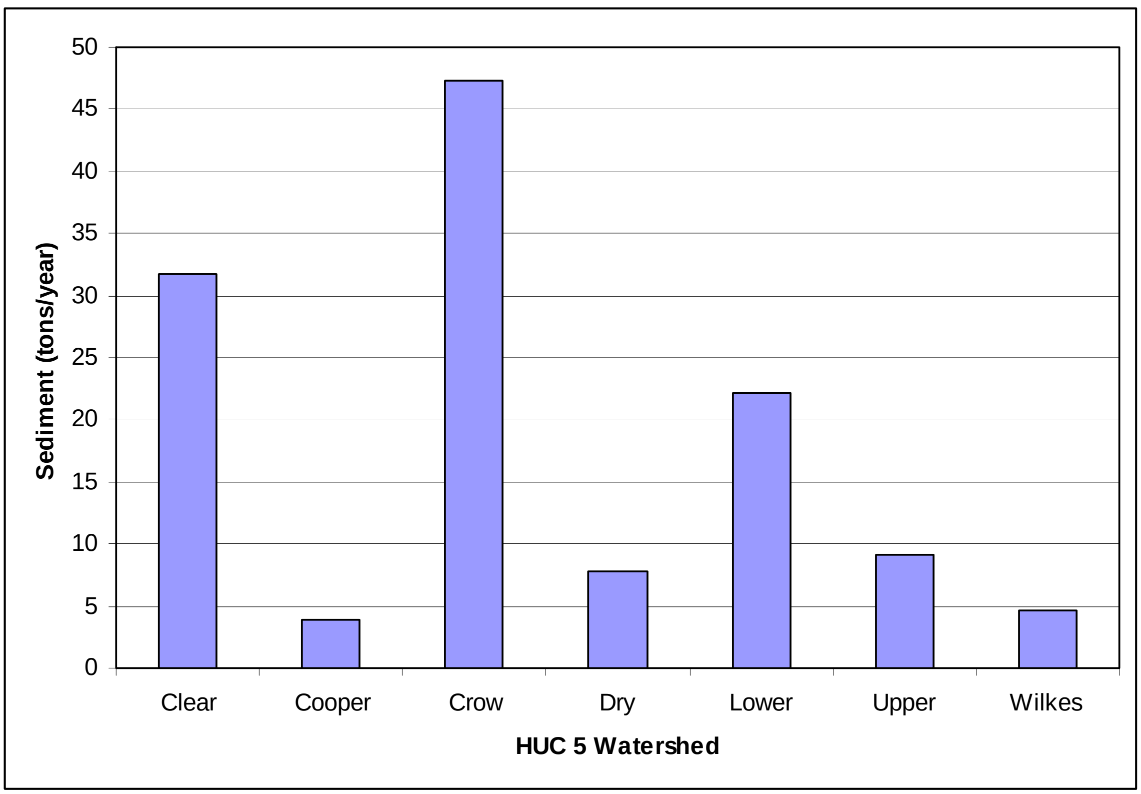


Figure 5-4. XDRAIN-Calculated Extrapolated Sediment Load from Road Surface Erosion

BMP upgrades and road closures typically are reflected in model results initially as an increase from ground disturbance associated with the upgrades or closures followed by an overall decrease in average annual sediment load. Several examples of this may be found in the Prospect Creek watershed. In Cooper Creek, BMP upgrades were implemented in the upper Chipmunk area (Cooper Creek) in 2003. Roads in the Mosquito Peak area (Clear Creek) received similar improvements in 2003. Road 2179 (Antimony Creek) was brought up to BMP standards in 2004 and Road 876 in 2003 (Cox Gulch). Partial BMP upgrades were installed on Road 352 (Dry Creek) in 2004.

Since the time of this modeling study, additional road closures and improvements have occurred in the Prospect Creek watershed on Crow Creek, Daisy Creek, and West Crow Creek. These activities and potential future restoration projects are discussed further in **Section 8.0**.

This study makes the assumption that most sediment from the road network is provided by the road conditions and contributing lengths leading to the streams at road/stream crossings. While this may be a reasonable assumption for determining the sediment loads from roads at road crossings it does not necessarily evaluate the full impact road systems have on watersheds. Road density, road proximity to streams, and road condition can all influence a streams ability to fully support beneficial uses as they may lead to modifications in the hydrologic conditions of the watershed. These and other impacts can lead to impairment from causes such as habitat alteration and other forms of “pollution” for which a TMDL is not developed. Further information regarding road/stream interaction in the Prospect Creek watershed is provided in Appendix B.

5.3 Bank Erosion

5.3.1 BEHI Methods

Data collected during the 2004 bank erosion inventory provided the basis for estimating average annual sediment loading from stream banks on mainstem Prospect Creek and tributary streams. RDG walked the entire length of Prospect Creek mainstem reaches 2 - 5 and the lower reaches of Clear, Cooper, Crow, and Dry creeks in July 2004. Measurements were recorded at a subsample of segments representing approximately 25% of the total main stem length. For example, on the main stem, four-hundred foot bank lengths were sampled at 1200-foot intervals. Measurements were then applied to the Bank Erosion Hazard Index (BEHI (Rosgen, 2001)) to determine loads from eroding banks. Tributary main stems and portions of their tributaries (Dry, Clear, Crow and Cooper Creeks) were also inventoried using the same sampling method. **Figures 5-5 and 5-6** show inventoried reaches and identified eroding banks.

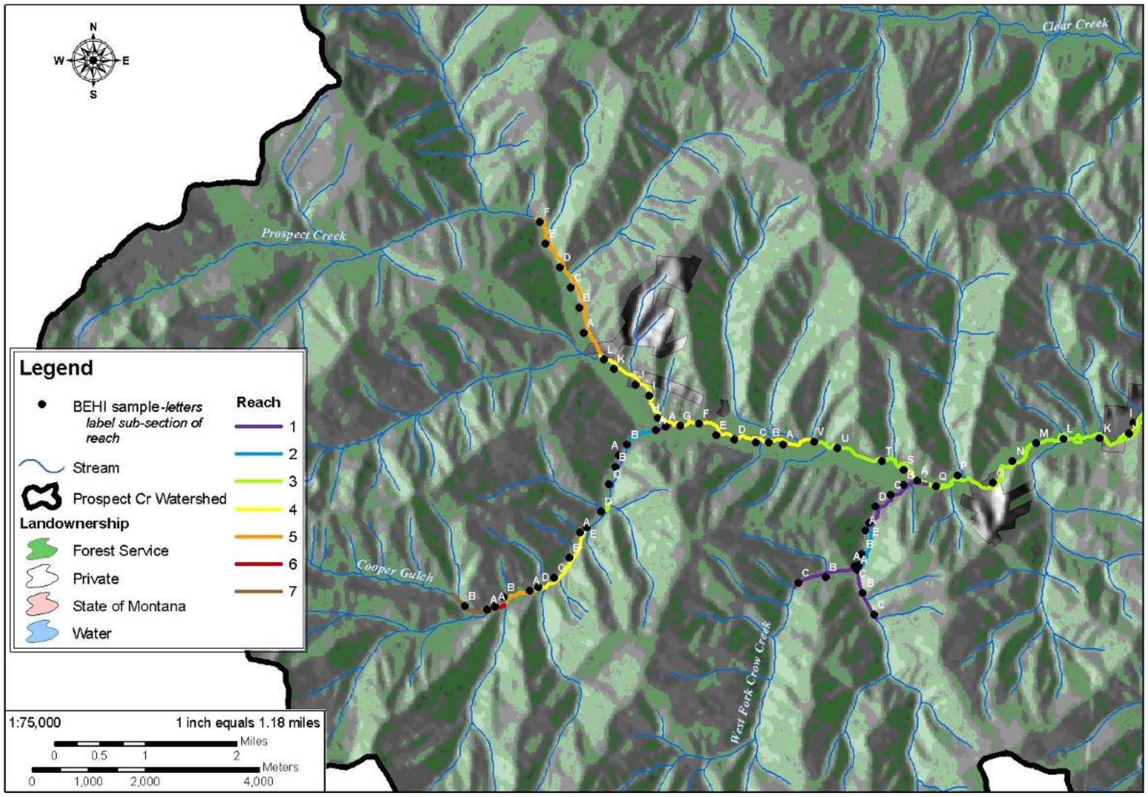


Figure 5-5. Map of Prospect Creek TMDL Upper Watershed BEHI Sample Sites

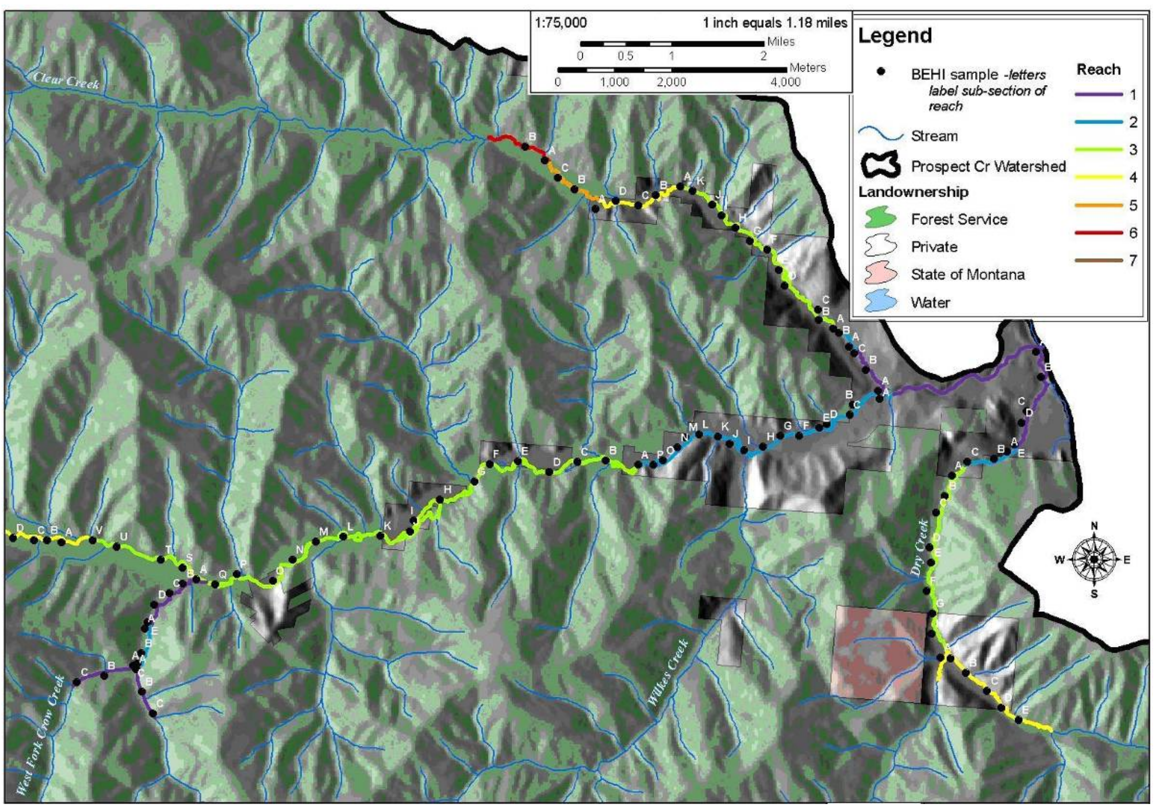


Figure 5-6. Map of Prospect Creek TMDL Lower Watershed BEHI Sample Sites

To estimate the average annual sediment load produced by eroding banks, an average rate of bank erosion was determined for each inventoried bank erosion site. Bank erosion rates were not field measured but were instead estimated on bank erosion rates calculated by David Rosgen for the Colorado Front Range (Rosgen, 2001). Of the available literature values, bank erosion related to glaciated, metasedimentary belt rock geology characterizing the Colorado Front Range is most similar to the geology of the Prospect Creek drainage.

Average annual sediment loading was estimated by multiplying the length and height of each eroding bank by the determined erosion rate to get cubic feet per year, dividing by 27 to convert to cubic yards per year, and multiplying by 1.3 to get tons per year. This assumes the dry bulk density of one cubic yard of bank material is 1.3 tons.

When appropriate, field surveyors assigned a contributing anthropogenic influence to each eroding bank based on visual evidence and best professional judgment. In the case of multiple influencing factors, percent contribution was assigned accordingly. It is acknowledged the assignment of bank erosion influence among the anthropogenic factors in the watershed is coarse and based on best professional judgment; however it does provide some direction for prioritizing restoration efforts and identifying relative contributions.

To account for the average annual sediment loading in uninventoried reaches, average annual sediment loading rates from inventoried reaches were extrapolated to the portions of each tributary that were not field inventoried. Total average annual sediment loads were summarized by stream and by human-related versus non-human related sources.

5.3.2 BEHI Results

Inventoried Banks

Results indicate that approximately 17,872 tons/year of sediment are delivered to the Prospect Creek drainage network from the inventoried stream segments. A comparison of average annual sediment loading by human-related versus non-human-related influences is presented in **Table 5-4**. Inventoried bank erosion from human-related influences accounts for 13,341 tons (75%) of the total average annual sediment load. An additional 4,531 tons (25%) are associated with either natural causes or causes which were undetermined. **Figure 5-7** presents these results graphically.

Table 5-4. Average Annual Bank Erosion Sediment Loading (Tons/Year) from Inventoried Banks

Load is differentiated by human- versus non-human-related influences					
Stream Name	**Human-Related**		**Non-human-Related (natural or undetermined)**		
	(t/y)	%	(t/y)	%	Total
Prospect Cr	10,695	81	2,489	19	13,184
Clear Cr	399	31	899	69	1,298
Cooper Cr	771	83	160	17	931
Crow Cr	1,004	85	173	15	1,177
Dry Cr	472	37	810	63	1,282
	13,341	75	4,531	25	17,872

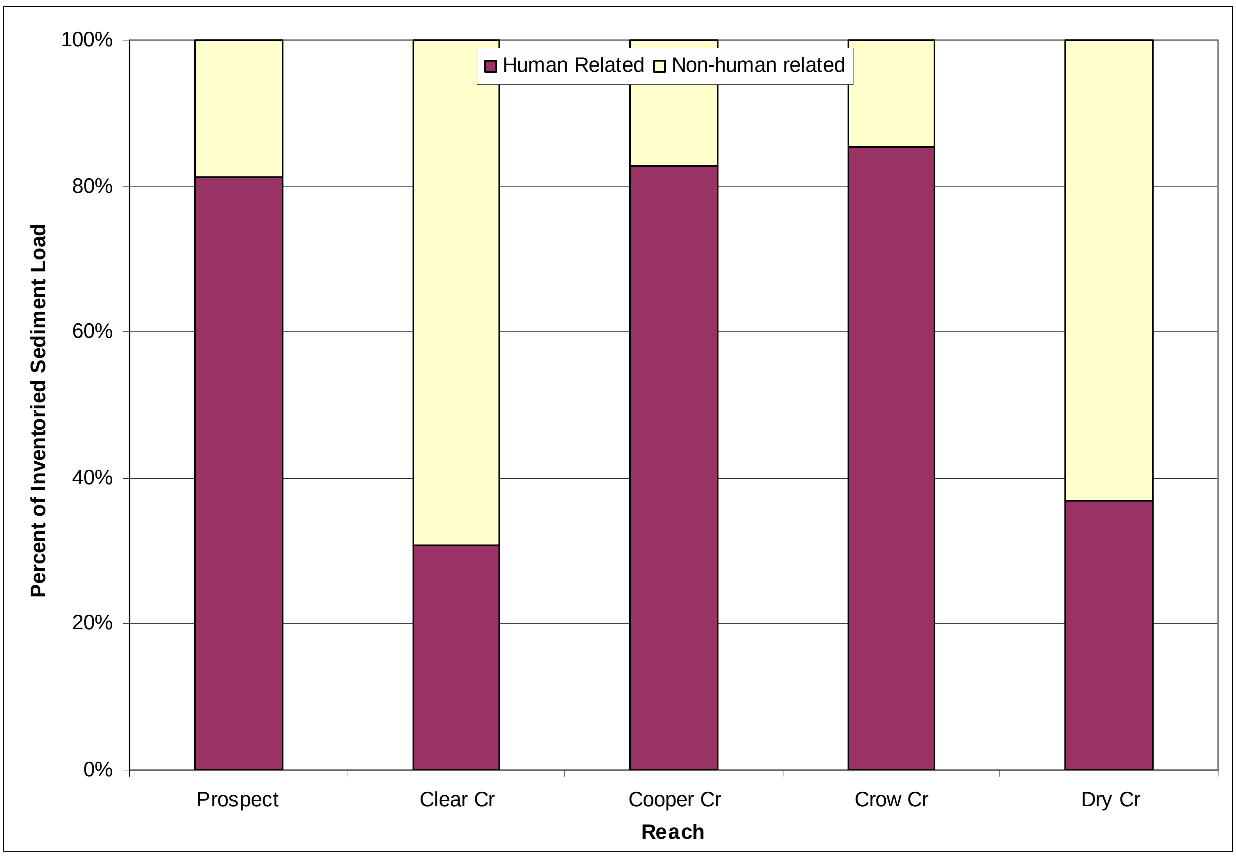


Figure 5-7. Percent of Inventoried Average Annual Sediment Load from Bank Erosion Differentiated by Human- Versus Non-Human Related Influences
Human-related influences include channel relocation or armoring, roads, utility corridors, or riparian modification.

Table 5-5. Average Annual Bank Erosion Sediment Loading (Tons/Year) From Inventoried Banks of Prospect Creek and Tributaries

Load is differentiated by different types of human-related influence. Values are not cumulative. Many bank erosion sites were attributable to multiple human-related influences.\

	Bank Stabilization / Rip Rap	Roads	Utilities#	Private Residence	Riparian Modification*
Prospect Cr	1860	5926	10498	1404	11426
Clear Cr	74	355	0	166	1277
Cooper Cr	0	136	722	0	280
Crow Cr	0	118	946	0	1117
Dry Cr	17	412	60	17	1273

* Riparian modification includes a wide range of riparian vegetation removal, from extensive modification as a result of clear cutting to accommodate roads or utilities to limited modification as evidenced by several or more tree stumps. Riparian modification was almost always noted along with the other identified human-related influences. # Utilities include NWE, YPL, and BPA.

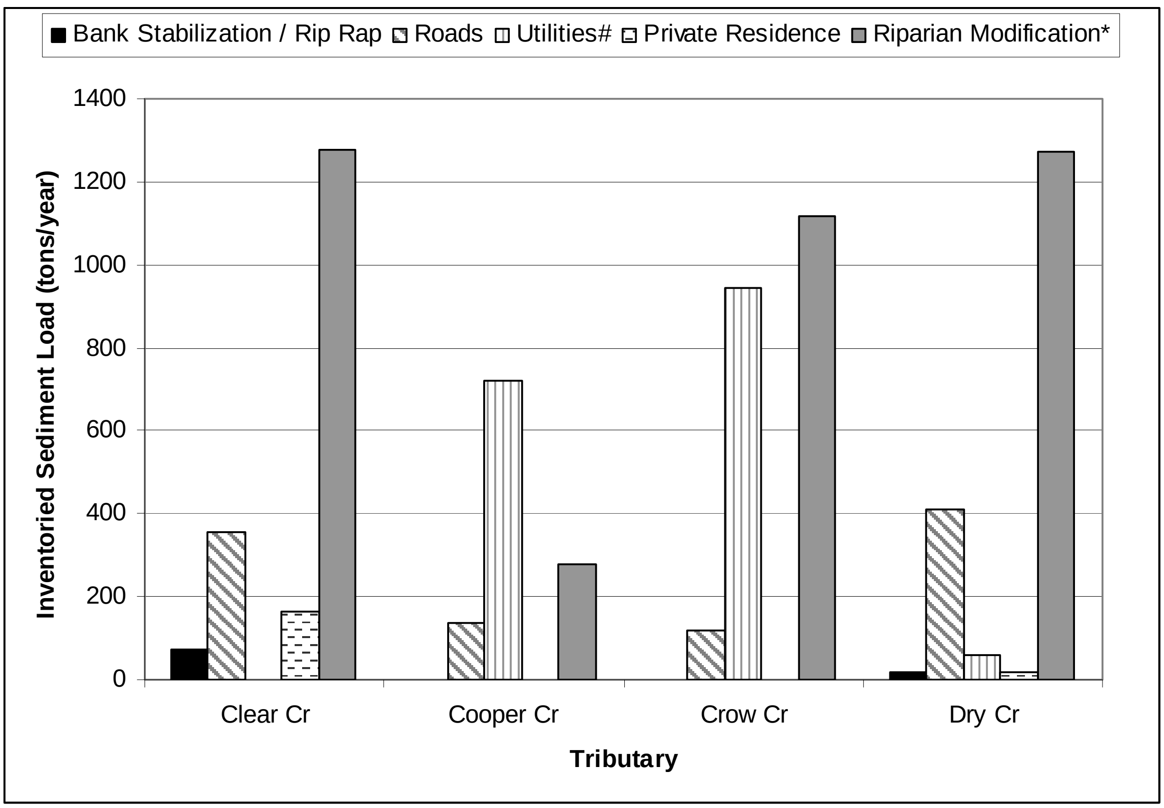


Figure 5-8. Average Annual Bank Erosion Sediment Loading (Tons/Year) from Inventoried Banks of Prospect Creek Tributaries

Load is differentiated by different types of human-related influence. Values are not cumulative. Many bank erosion sites were attributable to multiple human-related influences.

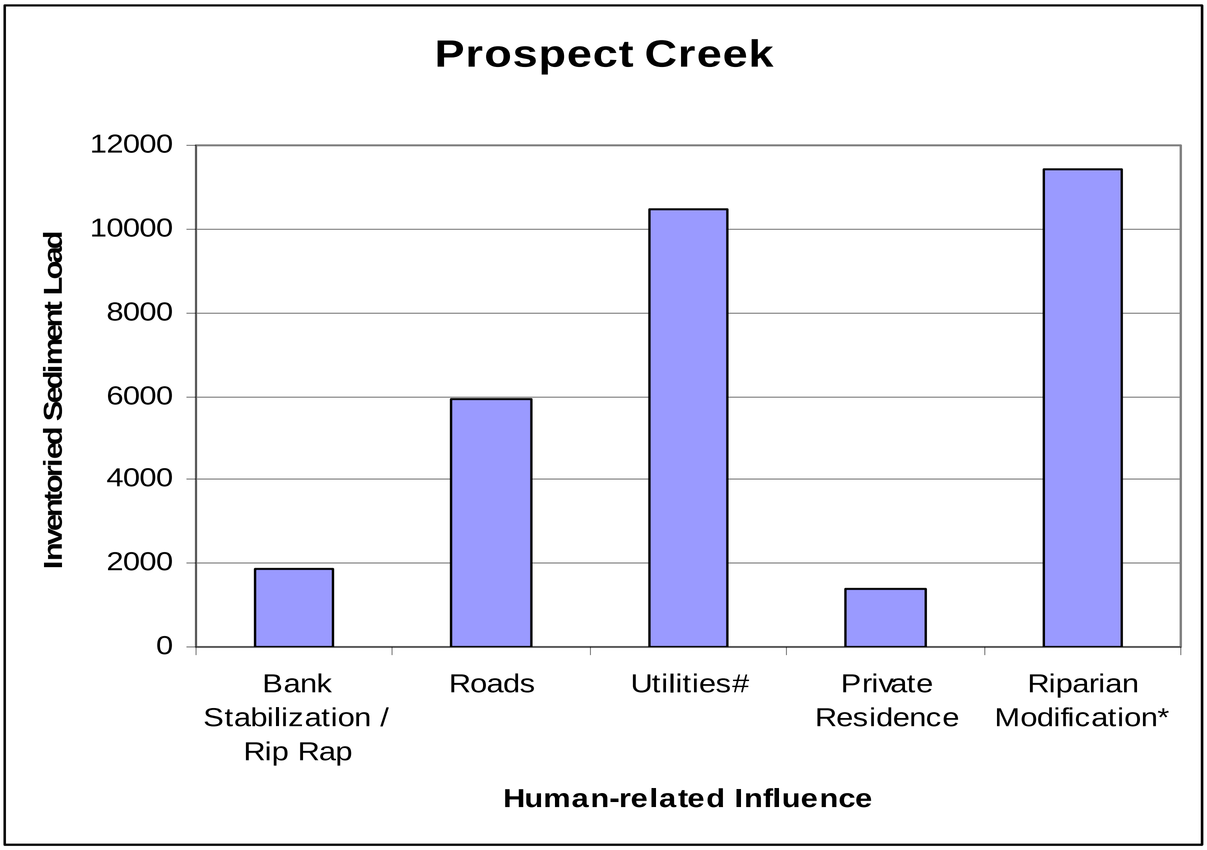


Figure 5-9. Average Annual Bank Erosion Sediment Loading (tons/year) from Inventoried Banks of Prospect Creek
Load is differentiated by different types of human-related influence. Values are not cumulative. Many bank erosion sites were attributable to multiple human-related influences.

Total Extrapolated Average Annual Bank Erosion Sediment Load
Additional load is likely contributed from stream segments not included as part of the 25% bank erosion sub-sample. Average annual sediment loading rates calculated from the inventoried segments were applied to the uninventoried segment lengths to derive an extrapolated average annual sediment load for the uninventoried segments. The total calculated (inventoried segments) and extrapolated (uninventoried segments) average annual sediment loading was combined to get a total average annual load from bank erosion. Inventoried sediment loads, extrapolated sediment loads and total sediment load from bank erosion are presented in **Table 5-6**. The total sediment load is presented graphically in **Figure 5-10**.

Inventoried results were extrapolated to C stream types, potential C stream types which are currently classified as D stream types and combination C stream types which have small B inclusions. The inventoried results were applied to these reach types because the geomorphology associated with them is more sensitive to anthropogenic influence, and is more likely to accommodate human activities that would lead to anthropogenic influenced bank erosion. Streams or stream types that are not sensitive or unlikely to have anthropogenic influence did not have inventoried results applied to them so as not to inflate bank erosion loads throughout the

watershed. Extrapolation did not include A, B or F reaches and did not include any reaches in the following segments:

- Upper Cooper Gulch from about 1 mile upstream from Summit Creek
- Forks of Clear Creek
- Lower most Prospect Creek below Dry Creek confluence
- Prospect Creek above Twenty-three mile Creek
- East and west Forks of Crow Creek above the lowest C sections
- Wilkes Creek upstream from about 1 mile above private inclusion
- No Wilkes
- East Fork Dry upstream of private
- West Fork Dry Creek upstream from lowest D section in private

The total average annual bank erosion load to Prospect Creek including inventoried and uninventoried segments of Prospect Creek mainstem and select tributaries is 67,447 tons per year or approximately 3,200 tons/mile/year. Of the tributaries, Crow Creek has the greatest average annual sediment loading rate from bank erosion at approximately 1,300 tons/mile/year followed by Cooper and Clear creeks, both just under 1,000 tons tons/mile/year. Dry Creek has the lowest average annual sediment loading rate (700 tons/mile/year).

Table 5-6. Inventoried Bank Erosion and Extrapolation for Human Caused and Natural Sediment Load

Stream	Inventoried Length (miles)	Inventoried Sediment Load	Uninventoried Length	Sediment Load Extrapolated to Uninventoried Banks (tons/yr)	Total Length	Total Sediment Load (tons/yr)	Human vs Natural Load Ratio	Extrapolated Human Caused Load	Extrapolated Natural/Unattributed Load
		(tons/yr)	(miles)		(miles)		(%)		
Prospect	4.1	13184	11.6	36839	15.7	50023	81/19	40519	9504
Clear	1.4	1298	5.1	4860	6.5	6158	31/69	1909	4249
Cooper	1	931	2.7	2628	3.7	3559	83/17	2954	605
Crow	0.8	1178	2	2412	2.8	3591	85/15	3052	539
Dry	1.3	1281	4.5	4312	5.8	5593	37/63	2069	3524
		17872		51051		68923	73/27	50503	18421

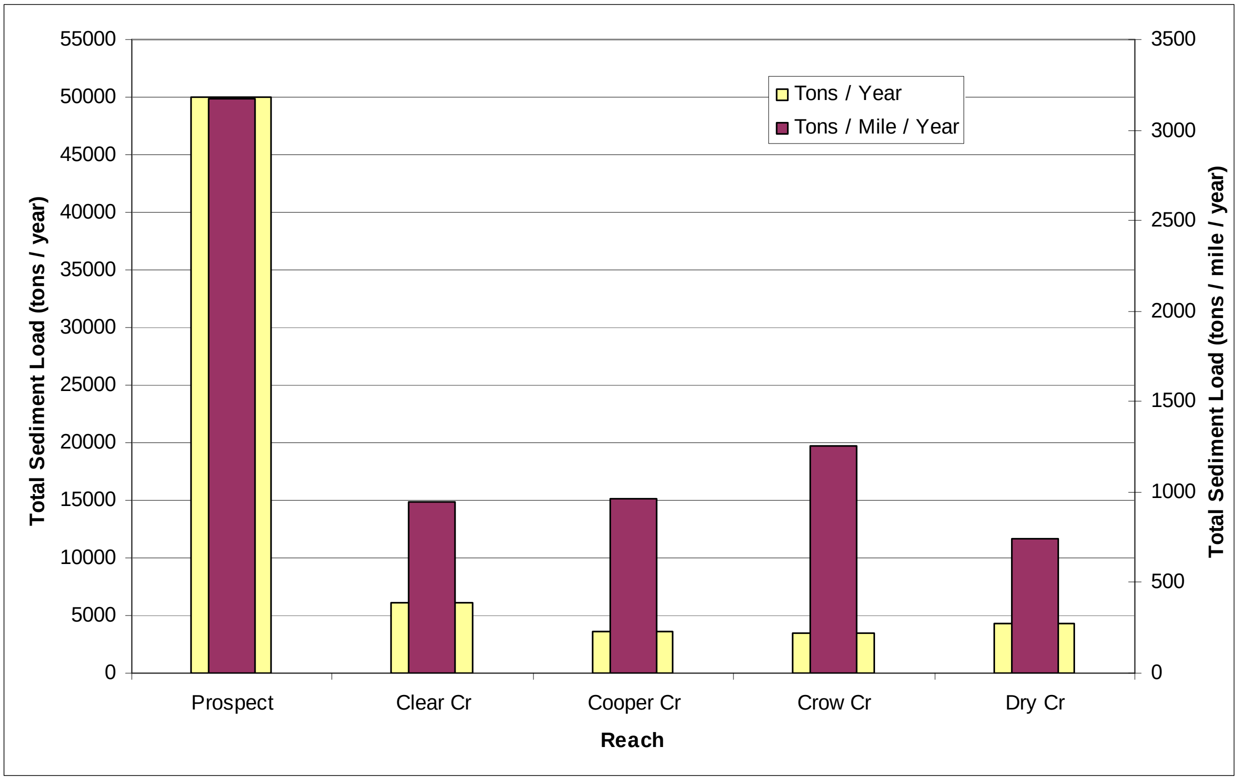


Figure 5-10. Average Annual Bank Erosion Sediment Loading (tons/year) from Inventoried Banks and Extrapolated to Un-inventoried Banks

5.4 Traction Sand

5.4.1 Traction Sand Methods

GIS analysis was used to divide the Prospect Creek road, State Secondary Highway 471, into segments for data collection and analysis of sediment contribution from winter road sanding and snow plowing. The DOQQ image for Prospect was used to on-screen digitize the river-left (facing downstream) bank or river-left edge of the flood prone area and the south shoulder of the highway below Crow Creek. Above the Highway bridge at Crow Creek, the opposite bank and floodprone edge were digitized, the sides closest to the highway. The highway shoulder was buffered at several intervals including 25, 50, 100, 200, 300, 400, and 500 feet. Buffer polygons were then intersected with the stream bank/floodprone edge layer to break out the stream segments into categories according to distance from road edge.

Consideration of sand delivered to the floodprone area, while not immediate, direct delivery to the active bankful channel, is important when determining the potential contribution of the sediment source to water quality. Sand deposited on the floodprone area in a “dry” year, one in which peak flows do not rise above bankfull elevation or only partially inundate the floodprone area, will most likely remain where initially deposited. In a “wet” year when the floodprone area is inundated, a portion of traction sand deposited in previous years may be mobilized by flood flows or snow melt runoff and incorporated into the streams sediment load.

In mid-July 2004, field data were collected at sites with the potential of receiving road sanding sediment, primarily those at stream crossings and those road segments within 100 feet of stream bank or floodprone area (**Figure 5-11**). The surveyed crossings included bridges and culverts as well as ditch relief culverts identified as linking road sand to the mainstem channel network. The 100-foot distance was selected based on findings in a St. Regis River TMDL study which found most traction sand is deposited within 45 feet of the sanded highway. The same study also observed a maximum dispersal distance of 112 feet from the sanded highway.

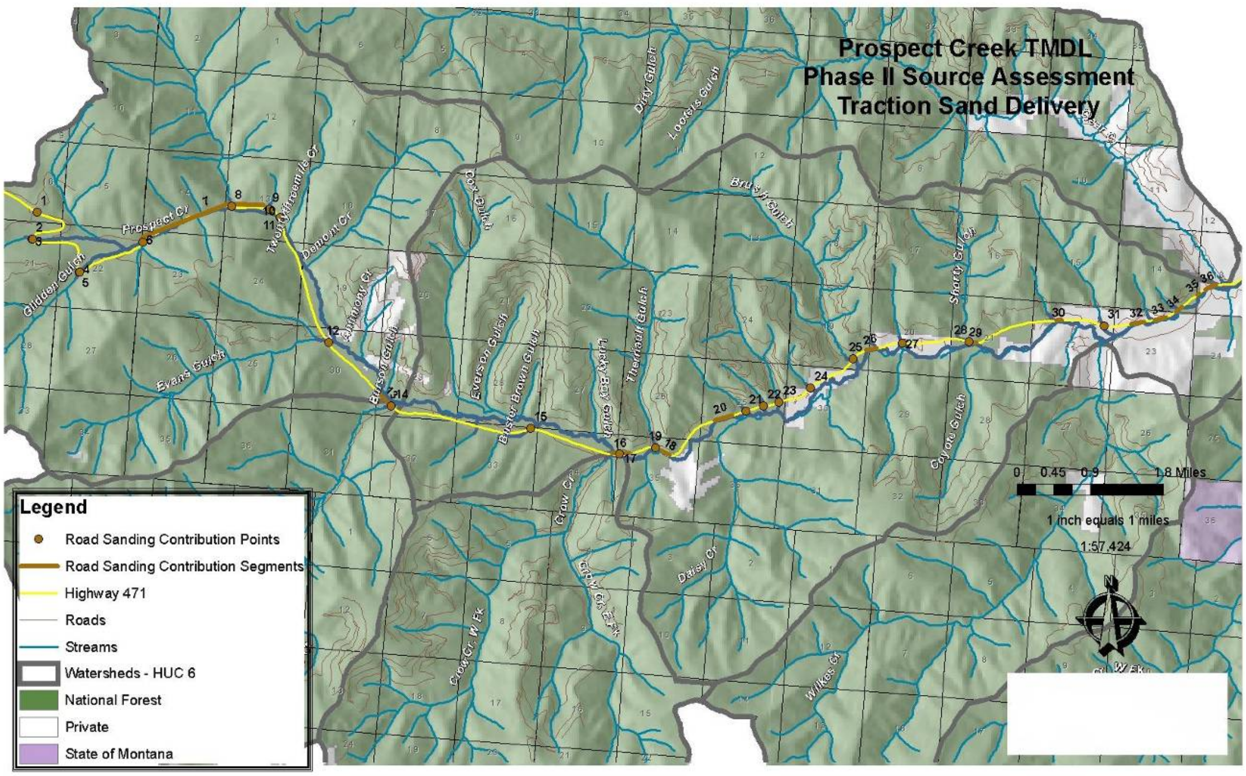


Figure 5-11. Traction Sand Contribution Points and Segments

Parameters measured and recorded at each site included the type of feature (crossing or road segment), contributing sides (inlet and/or outlet for crossings and left and/or right for road segments); gradient (percent) of the vegetative buffer slope, if any, between the road shoulder and Prospect Creek or connected channel; buffer slope length (feet), buffer mitigation category; and contributing length of road (feet). Also noted at each site was whether delivery of road sand was evident. Photos were taken at each site.

Montana Department of Transportation (MDT) provided sand application totals for Highway 471 for four recent winters (**Table 5-7**). It is assumed that sand is distributed at a relatively constant rate along the 22 miles of road (Stimson, E., pers. comm., 2004). Prospect mainstem Reach 6, which extends from the headwaters to approximately 0.5 miles below Twentyfourmile Creek, is coincident with the upper six miles of highway. The upper six miles of highway are not plowed or sanded from about December to March. However, plowing and heavy sanding in October and November and again in the spring offset the lack of application through the rest of the winter

months (Stimson, E., pers. comm., 2004). Based on this information, the average annual application rate, 72.1 tons/mile/year (**Table 5-8**), distributed evenly over the 22 miles of road equates to 0.014 tons/foot/year (72.1/5280 = 0.014).

Table 5-7. Highway 471 Annual Sand and Magnesium Chloride Application Statistics

Winter	Sand (tons)	Magnesium Chloride (gallons)
2000-2001	2181	0
2001-2002	1769	1860
2002-2003	1050	3024
2003-2004	1349	3541
Average	**1587.3**	**2106.3**
Reference: Montana Department of Transportation, 2004		

Effects of magnesium chloride application were not part of this investigation. Recently (2003-2004) MDT has monitored chloride levels in Prospect Creek. The unpublished results of their monitoring show little to no increase in chlorides above background (tributary) levels, indicating a minimal effect to water quality in Prospect Creek from application of magnesium chloride to Highway 471.

Table 5-8. Annual Sand Application Rates for Sections of Highway 471

Winter	Sand (tons)	Magnesium Chloride (gallons)
2000-2001	99.1	0.019
2001-2002	80.4	0.015
2002-2003	47.7	0.009
2003-2004	61.3	0.012
Average	**72.1**	**0.014**

The average annual application rate (0.014 tons/foot) was assigned to all inventoried field sites. Bridges, crossings and road segments with no buffer vegetation and/or zero slope lengths received a delivery ratio of 1, assuming 100% of sand applied to the highway in these areas is delivered to the stream channel or to the floodprone area. Conversely, crossings and segments with greater than 60 percent vegetation buffer and/or buffer slope length greater than 100 feet received a delivery ratio of 0, assuming none of the sand applied in those segments reached the stream channel or floodprone area. Within the range of 0 to 1, delivery ratios decreased with increasing vegetation cover in the buffer and decreased with increasing slope distance (**Table 5-9**).

Table 5-9. Delivery Ratio for Varying Buffer Slope Lengths and Degrees of Mitigating Buffer Vegetation

Buffer Slope Length Class	0% Vegetation Cover	1-20% Vegetation Cover	20-60% Vegetation Cover	> 60% Vegetation Cover
0-25’	1.0	0.8	0.5	0.3
25-50’	0.8	0.6	0.4	0.2
50-100’	0.6	0.5	0.3	0.1
>100’	0.4	0.3	0.2	0.0

Five other crossings along Prospect Creek Reaches 2 and 3 were identified from GIS layers, but were not located in the field. It is assumed that some traction sand is contributed to the channel network at these locations. The minimum sand contribution from all measured contributing crossings (1.4 tons per year) was assigned to each of these crossings not located.

5.4.2 Traction Sand Results

Modeled results of traction sand application and delivery are provided in **Table 5-10**.

Table 5-10. Traction Sand Application and Delivery Estimates

		Sand Applied (tons/year)	Sand Delivered+ (tons/year)	Sand Delivered * (tons/year)
All Inventoried Segments and Crossings	Total	**397.3**	**208.5**	**215.5**
	Average	12.8	6.7	6.0
	Min	1.4	1.4	1.4
	Max	147	58.8	58.8
	StDev	25.3	10.3	9.7
Road Segments Only	Total	**120.8**	**81.9**	**81.9**
	Average	10.1	6.8	6.8
	Min	2.8	2.1	2.1
	Max	21	16.8	16.8
	StDev	4.6	4.5	4.5
Crossings Only	Total	**46.9**	**34.0**	**41.0**
	Average	4.7	3.4	2.7
	Min	1.4	1.4	1.4
	Max	10.5	8.4	8.4
	StDev	3.1	2.4	2.2
+ Does not include estimate for 5 un-located crossings. * Includes estimate of 4.1 tons/year for each of 5 un-located crossings.				

This analysis does not account for county road sanding which could enter Prospect Creek above Dry Creek and could enter Dry Creek just above it’s confluence with Prospect Creek. Based on the Highway 471 calculations, similar sanding operations might result in an additional 1 ton of sand delivered to lower Prospect Creek at these entry points.

5.5 Other Sediment Sources

Mass wasting was not observed in the Prospect Creek watershed during air photo review or field surveys. Mass wasting is not considered here as a source of sediment loading.

Potential sediment contribution from culvert failure is presented in Appendix H.

5.6 Summary

The following table (**Table 5-11**) provides a summary of quantified loads from each of the major source categories and brief summary description of each source.

Table 5-11. Summary of Quantified Sediment Loads for Each Major Source Category in Each HUC 6 Watershed

	Upper Prospect	**Lower Prospect**	**Dry**	**Clear**	**Crow**	**Cooper**	**Wilkes**	**Prospect Creek Watershed**
Sources								
Natural Hillslope Erosion (LoloSed)	187	177	206	147	87	133	74	1011
Timber Harvest (Lolo Sed)	2.4	0	0	0.2	0	2	0	5
Roads (XDRAIN)	9.2	22.1	7.8	31.7	47.3	3.9	4.6	127
Culverts	217	55	44	144	61	30	32	583
Bank Erosion								
Attributed to Natural	2070	7434	3524	4249	539	605	0	18421
Attributed to Anthropogenic	8826	31693	2069	1909	3052	2954	0	50503
Traction Sand	107.75	107.75						216
TOTAL SEDIMENT LOAD	**11419**	**39489**	**5851**	**6481**	**3786**	**3728**	**111**	**70865**

Sediment from Hillslope Erosion Associated with Timber Harvest
The LoloSed model used to determine the sediment loads from timber harvest was based on known timber harvest activity from 1990 to 2004. No significant harvest has occurred in recent years. Based on the declining load from timber harvest over the years, as of now, very little sediment is contributed. Upper Prospect, Clear, and Lower Prospect supply a very small amount while the rest of the watershed does not supply any sediment. Renewed harvest activity in the area would likely increase loads and any activity should ensure all reasonable land, soil, and water conservation practices are employed during and after harvest to minimize the water quality impacts.

Sediment from Roads
Based on the XDRAIN analysis, Crow Creek and Clear Creek are the two largest contributing watersheds of sediment from roads. XDRAIN looks at road design, contributing length, soil type, and climate for those road segments that drain to a road-stream crossing. Reducing contributing road length and installing road BMPs such as water diversions and appropriate buffers, as well as road decommissioning or relocating when appropriate, may lead to significant sediment reductions.

Human-influence Bank Erosion
Bank erosion loads are greatest in along the Prospect Creek mainstem although it should be noted that this also accounts for a longer stream and therefore more banks with issues. When looking at the ratio of human caused vs. naturally influenced bank erosion then Prospect, Cooper, and Crow are all predominated by anthropogenically attributed bank erosion.

Traction Sand
Prospect Creek is the main stream affected by traction sand. Traction sand delivery was determined based on road length, design, and associated buffer characteristics.

Potential Load from Culverts
From the analysis presented in Appendix H, upper Prospect and Clear creek have the largest number of culverts and the therefore the greatest potential load at risk given abnormal high flow conditions. Of the culverts analyzed, Dry Creek, Clear Creek, and Lower Prospect are the only watersheds with actual documented sediment load potential, however a limited number of culverts were sampled (22 of 307) and results extrapolated to derive sediment potential across the watershed. Further investigation should be pursued to identify culverts at risk and prioritize culverts for improvement.

Discussion
Sediment from timber harvest, sediment from roads, human-influenced bank erosion, traction sand, and potential culvert failure are the significant sources of sediment in the Prospect Creek Watershed. Although the methods used to quantify the source loads vary, and therefore make it difficult to compare to each other, the information collected still allow prioritization for which watersheds are most affected by which source. In doing so it can help focus implementation efforts towards the development of the most effective strategies for reducing sediment in each respective HUC 6 watershed.

Table 5-12. Relative Rankings of Source Categories

Source Category	Upper Prospect	Lower Prospect	Clear	Cooper	Crow	Dry
Bank Erosion	2	1	6	4	3	5
Roads	4	3	2	6	1	5
Timber Harvest	1	4	3	2	4	4
Culverts	1	4	2	6	3	5
Road Sand	1	1	2	2	2	2
Relative Ranking[1]	9	13	15	20	13	21

[1]The relative ranking is merely the sum of the ranks for each subwatershed. The lower the number, the greater the potential for sediment loading.

The relative rankings show that the Upper and Lower Prospect Creek watersheds are the most significant areas of sediment input, followed by Crow Creek, Clear Creek, Cooper Creek, and Dry Creek respectively. These rankings were based on the sediment load from each subwatershed, but not normalized by area.

The sediment loading described in this section does not differentiate between fine and coarse sediment however the sources analyzed in this assessment contribute varying amounts of one or both. Depending on the source, the impacts to the resource are varied based on the relative contribution of fine or coarse sediment. Fine sediment from sources such as hillslope erosion from timber harvest may have a significant impact on aquatic life and cold water fishery success due to loss of spawning habitat, lack of interstitial spaces in substrate to support macroinvertebrates, turbidity increase, etc. Coarse sediment loads from sources such as bank erosion may lead to significant alterations in channel form and function leading to loss of pools, stream over-widening, and changes in channel pattern. In the Prospect Creek watershed, both sediment load types are evident and reflected in the known sources and data presented in **Section 4.0**, and both types have a definite impact on the beneficial uses. In order to ensure proper protection of uses throughout the Prospect Creek watershed, both fine and coarse sediment loading must be reduced and therefore are not differentiated for analysis.

SECTION 6.0
TMDLS & LOAD ALLOCATIONS

6.1 Introduction

The technical definition of TMDL is "the sum of load allocations plus waste load allocations plus a margin of safety." The load allocations apply to nonpoint sources and the waste load allocations apply to point sources covered by a Montana Pollutant Discharge Elimination Systems Permit. There are not any permitted sediment discharges in the Prospect Creek Watershed and wasteload allocations are therefore not considered a necessary part of this TMDL. In addition, the TMDL includes a margin of safety (MOS) that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving stream. A TMDL is expressed by the following equation:

$$TMDL = \Sigma WLA + \Sigma LA + MOS$$

The TMDL can be expressed through appropriate measures other than a given loading rate (40 CFR 130.2). The use of an alternative approach for sediment TMDL analysis is justified in guidance developed by EPA (EPA, 1999) given the uncertainties around sediment TMDL development. The approach used for the Prospect Creek watershed is to express the TMDL as a percent reduction in loading based on reductions applied to controllable human sources. These percent reductions applied to controllable human sources are the basis for sediment load allocations that cumulatively define the TMDL. The source load reduction percentages used for load allocations are based on departure from target conditions, estimates of human associated loads above natural background, achievable reductions, and best professional judgment.

As shown in **Section 4.0**, loading conditions and departure from sediment impairment indicators vary between the major streams in the Prospect Creek watershed. Analysis of sediment contribution throughout the watershed was conducted at the HUC 6 watershed scale and based on the major sources identified in **Section 5.0**. The Prospect Creek watershed is composed of six HUC 6 watersheds. Sediment TMDLs have been developed for Prospect Creek, Clear Creek, and Dry Creek. The allocations pertaining to Prospect Creek encompass all six HUC 6 watersheds. The TMDL for Prospect Creek is applied to all cumulative loading along the length of Prospect Creek. Allocations are developed to ensure that water quality standards for sediment are met along all of Prospect Creek. The TMDLs for both Clear Creek and Dry Creek are also applied to all cumulative loading along the length of each stream. Allocations for Clear Creek and Dry Creek are specific to each respective HUC 6 watershed and are also developed to ensure that water quality standards for sediment are met along the whole length of each stream.

6.2 Seasonality and Margin of Safety

All TMDL documents must consider the seasonal variability, or seasonality, on water quality impairment conditions, maximum allowable pollutant loads in a stream (TMDLs), and load allocations. TMDL development must also incorporate a margin of safety into the load allocation process to account for uncertainties in pollutant sources and other watershed conditions and must

ensure (to the degree practicable) that the TMDL components and requirements are sufficiently protective of water quality and beneficial uses. This section describes the considerations of seasonality and a margin of safety in the Prospect Creek TPA sediment TMDL development process.

6.2.1 Seasonality

Sediment loading varies considerably with season. For example, sediment delivery increases during spring months when snowmelt delivers sediment from upland sources and resulting higher flows scour streambanks. However, these higher flows also scour fines from streambeds and sort sediment sizes, resulting in a temporary decrease in the proportions of deposited fines in critical areas for fish spawning and insect growth. Because both fall and spring spawning salmonids reside in the Prospect Creek TPA, streambed conditions need to support spawning through all seasons. Therefore, sediment targets are not set for a particular season and source characterization is geared toward identifying average annual loads.

6.2.2 Margin of Safety

An implicit margin of safety (MOS) is provided by conservative assumptions for sediment loading, which are designed to ensure restoration goals will be sufficient to protect beneficial uses. These assumptions and considerations are discussed within the allocation section below. The margin of safety is to ensure that target reductions and allocations are sufficient to sustain conditions that will support of beneficial uses. An additional margin of safety is provided through an adaptive management approach that includes adjusting future targets and water quality goals based on monitoring outlined in **Section 9.0**. No explicit MOS is included in sediment TMDLs specified for each water body, rather an implicit MOS is included within the analysis of each source and the development of allocations.

6.3 Prospect Creek Sediment TMDL and Allocations

6.3.1 Prospect Creek Sediment Total Maximum Daily Load

Table 6-1. Sediment Allocations and TMDL for Prospect Creek

Sources		**Current Estimated Load (Tons/Yr)**	**Load Allocation (as percent reduction)**	**Resultant Estimated Sediment Load (Tons/Yr)**
Anthropogenic Nonpoint Sources	Bank Erosion	50,503	80%	10,101
	Forest Roads	127	50%	64
	Culvert Failure	399	77%	92
	Upland Timber Harvest	5	0%*	5*
	Traction Sand	216	31%	149
Natural Background		19,432	0%	19,432
Total Load		70,682	**TMDL = 58%**	29,838

* Future increases in loading are acceptable as defined in **Section 6.3.2.5**.

The total sediment TMDL for Prospect Creek is expressed as a 58% reduction in the total yearly sediment loading achieved by applying the load allocation reductions identified in **Table 6-1**. This is a reduction in both coarse and fine sediment loading to ensure full protection of beneficial uses. This 58% value is based on information provided in the **Section 5.0** (Source Assessment) and a determination that approximate reductions from the Prospect Creek watershed as a whole cumulatively account for an approximate 58% reduction in sediment load and is achievable by addressing the major human caused sources described in this section. The sediment load allocations to major sources and associated rationale behind the allocations are presented below. Total maximum daily loads explicitly expressed as daily loads are presented in **Appendix D**.

6.3.2 Allocations

Allocations are developed for significant sediment sources or source categories consistent with the total sediment TMDL. The allocation approach used in this section is based on load reductions or load limits applied to controllable sediment sources. This also includes allocations applicable to future activities/growth consistent with EPA guidance (EPA, 1999). This approach does not include development of load reduction allocations for natural background loading since natural background loading is not considered a controllable source.

The watershed characterization and source assessment information is used to identify source categories for developing sediment load allocations. As previously discussed in **Section 5.0**, the different methodologies for assessing loads vary to the extent that caution must be used when comparing loads from one source type in **Table 6-1** to another. Also, there is spatial variability in this loading to Prospect Creek, as well as the fact that some loading sources, particularly sources other than bank erosion, tend to be a higher percentage of fine sediment. Addressing many of these fine sediment sources from tributary and upper portions of the watershed is important to ensure that there are no fine sediment impairment conditions to fish habitat, particularly bull trout and cutthroat trout spawning habitat. These sediment source categories are discussed in further detail below.

6.3.2.1 Human Caused Bank Erosion

Allocation
80% reduction in bank erosion for all human related sources

Rationale
Most human caused bank erosion can be rectified through a combination of BMP implementation and active restoration/stabilization. It is acknowledged that the road and utility corridors in the Prospect Creek watershed may not allow for a full 100% reduction from human caused bank erosion. However, riparian corridor restoration in addition to a reduction in stream encroachment and the use of rip rap where possible will significantly improve bank stability along Prospect Creek.

Assumptions/Considerations:

- 80% of the human caused bank erosion in the Prospect Creek watershed can be rectified through BMP implementation and active restoration/stabilization
- It may take many years or decades before these measures are effective, particularly regarding those stream stability improvements linked to an increase in a mature riparian forest
- Active stream channel restoration efforts in the form of channel reconstruction may be desirable, based on further evaluations and peer review, to help accomplish the reduction in bank erosion and achieve an overall improved stream stability condition. At this time, this allocation neither requires nor restricts such active restoration efforts
- This allocation approach may need to be modified based on a more robust review of overall achievability
- A modification may require additional measures and a greater percent reduction to ensure that TMDL targets are met, or could conversely result in a lower percent reduction based on further analyses

6.3.2.2 Surface Erosion from Forest Roads

(specific to Road/Stream Crossing locations)

Allocation
50% reduction in sediment load from road surface erosion contributed at stream crossings (Based on XDRAIN study).

Rationale
Although no modeled scenarios were run with XDRAIN that predict the resultant sediment reduction once all BMPs are applied, DEQ has conducted various studies regarding surface erosion from forest roads throughout watersheds in western Montana. In the neighboring St. Regis watershed, which is also predominantly within USFS land, a similar study using WEPP found a reduction of 48% in sediment from surface erosion from forest roads once all BMPs were applied. Similarly, in the Ruby watershed, the Washington Method was applied and found a 60% reduction in sediment from roads is achievable once BMPs are applied. Therefore, a 50% reduction in the Prospect Creek watershed for erosion from forest roads is considered reasonable.

Assumptions/Considerations:

- Results from the St. Regis and Ruby road studies are comparable to the Prospect Creek watershed
- Not all roads within the Prospect Creek watershed are appropriately designed

This allocation can be accomplished through:

- Reduced road density to Moderate Classification (.7-1.7) where appropriate
- Remove or relocate high risk roads and roads with close proximity to streams
- Ensure all appropriate BMPs are implemented on all roads throughout the Prospect Creek watershed

6.3.2.3 Culverts

Allocation
77% reduction in average yearly sediment at risk from potential culvert failure

Rationale
This allocation applies to the average annual potential load that could occur as a result of a 100-year flow event, or the flow that equates to a recurrence interval of once per 100 years. Based on the culvert-failure analysis and extrapolation presented in **Appendix H** the risk of sediment contribution from potential culvert failures will be reduced if the restoration objective (load allocation) is met. The restoration objective is to upgrade all culverts to meet Q100 with Hw:D of less than 1.4. This objective is based on UFSF INFISH management objectives which call for all road stream crossings to be able to pass a Q100 flow event. 94% of the Prospect Creek watershed is owned by the USFS.

When interpreting the results of this culvert assessment, it must be understood that the modeled approach used does not reflect actual loads on any given year, but represents an average modeled load over a 100-year period. The annual culvert failure loads during low-flow years will likely be substantially less than given estimates, while annual loads during high-flow years (>Q50) may be higher than given estimates.

Assumptions/Considerations
- Culvert assessments were conducted on a small subset of culverts (24), which may not be representative of the larger set of crossings within the Prospect Creek watershed (307)
- After meeting Q100 capabilities, load at risk must not increase with the addition of new stream crossings and/or replacement of existing stream crossings that are undersized for any flows up to the 100 year event
- If new crossings are established that are less than the 100 year event, then existing crossings should be upgraded or removed to equally compensate for the increase in road fill at risk from the new crossing structure
- It may be more difficult for privately owned road-stream crossings to be upgraded to the Q100. These crossings should be upgraded to pass the largest flow possible given socioeconomic considerations.
- Consideration in culvert sizing must also be given to fish passage, the geomorphic effects such structures have on stream channels including sediment load (bank erosion and channel scour) and effects to fish habitat

6.3.2.4 Road Sanding

Allocation
31% reduction in tons of sediment per year from traction sand along with the reasonable application of traction sand for given road conditions.

Rationale
The sediment load from traction sand is based on the road sanding study described in **Section 5.0.** In that study, the delivery factor used to calculate the amount of sediment that reaches the

stream at a given location was based on a combination of the road slope and buffer slope and vegetation. The delivery factor is a function of the ability of the buffer to mitigate sediment input to the stream. Buffer mitigation is classified as low, medium, and high. For the purposes of developing a potential reduction, all sites with low buffer mitigation were given the typical delivery factor of 0.3 associated with medium buffer mitigation. Sites with delivery factors of 1.0 were not changed as it is assumed those sites occur at bridges and buffers do not exist. A 31% reduction in sediment delivery resulted from this improvement scenario.

It is recognized that traction sand is necessary to maintain safe travel conditions for winter months on the roads in the Prospect Creek watershed. In this case, “reasonable application” refers to applying the least amount of sand to the roads to maintain safe driving conditions. Conditions for any given year will vary, and therefore the amount of sand applied to the roads will be a function of the conditions at the time. However, since 2001, the Montana Department of Transportation has been able to reduce the amount of sand applied through the combined application of Magnesium Chloride. With the winters of 2002-03 and 2003-04 as a reference, a ratio of approximately 2.75 gallons of Magnesium Chloride per every ton of sand has been applied to Highway 471. It is therefore recommended that this application ratio be continued until future studies or methodologies find that the application of sand can be reduced further, with no negative impact to travel conditions or local biologic communities.

Assumptions/Considerations:

- Those locations identified with low buffer mitigation can be improved to a minimum of “medium”
- Delivery factors can be affected by improving buffer slope, buffer length, buffer density, contributing road length, or any combination of these factors
- Sand application is distributed evenly over the 22 miles of road

6.3.2.5 Timber Harvest

Allocation

No increase in sediment from timber harvest activities beyond what is contributed when all best management practices are implemented. This allocation is applied to the entire Prospect Creek watershed.

Rationale

This allocation addresses all forest management activities related to timber harvest such as clearing linked to timber harvest or recreational facilities, thinning of overgrown areas, prescribed fires, post-fire mitigation, etc. These activities, under existing conditions, were not considered significant sediment loads due in part to the limited amount of timber harvest that has occurred in recent years, and the relatively small contribution these activities have had on the sediment load, as modeled through the LoloSED analysis. Nevertheless, future timber harvest and other activities are a possibility and should not be precluded based on the Prospect Creek TMDL and this allocation as long as all BMPs and other protective efforts, such as INFS standards are pursued to ensure minimal sediment loading.

The exception to this allocation is where the total removal of canopy from timber harvest activities adds up to a cumulative increase in peak flow above 10% to the mainstem of Prospect Creek. When this occurs, any proposed timber harvest projects that will cause or contribute to increases above 10% will require additional analyses. This analysis must show how any additional bedload transport or additional bank erosion from peak flow increases or other hydrologic modifications within the watershed are consistent with the overall bank erosion and other load allocations for Prospect Creek.

Assumptions/Considerations
This allocation is to be accomplished as follows:

- Appropriate application of all forest harvest BMPs
- Adherence to Montana's SMZ law
- In addition to the SMZ law, no riparian harvesting within 125 of stream

6.4 Clear Creek

6.4.1 Sediment TMDL for Clear Creek

Table 6-2 Sediment Allocations and TMDL for Clear Creek

Sources		**Current Estimated Load (Tons/Yr)**	**Load Allocation (as percent reduction)**	**Resultant Estimated Sediment Load (Tons/Yr)**
Anthropogenic Nonpoint Sources	Bank Erosion	1909	80%	382
	Forest Roads	32	50%	16
	Culvert Failure	99	77%	23
	Upland Timber Harvest	0.2	0%*	0.2*
Natural Background		4396	0%	4396
Total Load		6436	**TMDL = 25%**	4817

* Future increases in loading are acceptable as defined in **Section 6.3.2.5**.

The total sediment TMDL for Clear Creek is expressed as a 25% reduction in the total yearly sediment loading achieved by applying the load allocation reductions identified in **Table 6-2**. This is a reduction in both coarse and fine sediment loading to ensure full protection of beneficial uses. This 25% value is based on information provided in the **Section 5.0** (Source Assessment) and a determination that approximate reductions from Clear Creek, and it's contributing tributaries, cumulatively account for an approximate 25% reduction in sediment load and is achievable by addressing the major human caused sources described in this section. The sediment load allocations and associated rationale behind the allocations are presented below.

6.4.2 Allocations

All allocations, rationales, assumptions and considerations are consistent with the Prospect Creek watershed allocations in **Section 6.3.2**. Identification of sources, and the development of reductions were applied throughout the Prospect Creek HUC 5 watershed to each HUC 6 subwatershed. The load values used for determining the Clear Creek TMDL are specific to the Clear Creek watershed, with the allocations based on the analysis at the Prospect Creek watershed scale.

6.5 Dry Creek

6.5.1 Sediment TMDL for Dry Creek

Table 6-3 Sediment Allocations and TMDL for Dry Creek

Sources		**Current Estimated Load (Tons/Yr)**	**Load Allocation**	**Resultant Estimated Sediment Load (Tons/Yr)**
Anthropogenic Nonpoint Sources	Bank Erosion	2069	80%	414
	Forest Roads	8	50%	4
	Culvert Failure	30	77%	7
	Upland Timber Harvest	0	0%*	0*
Natural Background		3730	0%	3730
Total Load		5837	**TMDL = 29%**	4155

* Future increases in loading are acceptable as defined in **Section 6.3.2.5**.

The total sediment TMDL for Dry Creek is expressed as a 29% reduction in the total yearly sediment loading achieved by applying the load allocation reductions identified in **Table 6-2**. This is a reduction in both coarse and fine sediment loading to ensure full protection of beneficial uses. This 29% value is based on information provided in the **Section 5.0** (Source Assessment) and a determination that approximate reductions from Dry Creek, and it's contributing tributaries, cumulatively account for an approximate 29% reduction in sediment load and is achievable by addressing the major human caused sources described in this section. The sediment load allocations and associated rationale behind the allocations are presented below.

6.5.2 Allocations

All allocations, rationales, assumptions and considerations are consistent with the Prospect Creek watershed allocations in **Section 6.3.2**. Identification of sources, and the development of reductions were applied throughout the Prospect Creek HUC 5 watershed to each HUC 6 subwatershed. The load values used for determining the Clear Creek TMDL are specific to the Dry Creek watershed, with the allocations based on the analysis at the Prospect Creek watershed scale.

6.6 Adaptive Management and Monitoring Recommendations

The adaptive management process allows for continual feedback on the progress of restoration activities and status of beneficial uses. Adaptive management may, at times, necessitate changing one or more components to improve ways of achieving and measuring success. Furthermore, the use of multiple lines of evidence (biological and physical) allow for a more robust measure of stream conditions. In order to track success and further refine the connections between sediment targets and beneficial use support, monitoring of in-stream sediment targets should be part of the adaptive management plan to meet water quality goals. This, in conjunction with efforts to improve the stream via implementation of allocations through BMPs and other watershed improvements, will allow for a better understanding of the effectiveness of the management strategies and permit adaptation over time. Effectiveness monitoring will include restoration progress tracking and also measuring sediment parameters to determine the effectiveness of restoration activities.

SECTION 7.0
NON-POLLUTANT IMPAIRMENTS AND TARGETS

7.1 Introduction

Several beneficial use support objectives have been identified where a pollutant is not linked directly to the negative beneficial use impairment. These objectives address conditions that negatively affect beneficial uses but are not otherwise addressed adequately via the TMDL target development. Use support objectives address fish passage and fish habitat (LWD).

7.2 Fish Passage

Human caused fish passage barriers that lead to undesirable fishery or aquatic life conditions can justify an impairment linked to habitat alteration.

Rationale and Applicability Considerations
Where fish passage is desirable, the presence of any significant human caused fish passage barrier can provide the basis for an impaired waterbody determination. This is because the fish passage problem can prevent a waterbody from fully supporting the cold-water fish beneficial use by restricting access to key spawning areas or refuge during flow or temperature fluctuations. In some cases, it may be desirable to keep a culvert or other type of barrier in place to prevent undesirable species from moving into areas they currently do not inhabit. Input from fisheries professionals and information from **Appendix H** will be used to determine where fish passage barriers are a significant concern.

7.3 LWD and Fish Habitat

The same values used for LWD as supporting targets (**Table 7-1**) also apply as a supporting target or objective to assist with habitat alteration impairment determinations.

Rationale
Woody debris is an important component for fisheries and aquatic life habitat as it aids in creating additional in-stream habitat, refuge areas, pool formation, morphology variability, and habitat for various life stages of fish and aquatic macroinvertebrates. A significant lack of LWD in comparison to a reference condition can provide a basis for an impairment determination due to loss of aquatic habitat.

Applicability Considerations
Not meeting the LWD supporting target, along with other indications of habitat problems, can justify an "other habitat alterations" impairment cause. Impairment determinations linked to LWD should generally be limited to smaller stream sizes, primarily those less than 35 feet bankfull width. It can be applied to larger C reaches where LWD retention is more likely. Statistical distributions of the individual stream or watershed data can be used to help evaluate overall LWD conditions relative to reference. Future monitoring of the streams of interest and

any reference streams should include identification of any linkages between LWD and increased refugia for fish.

Table 7-1. Summary of Use Support Objectives

Parameter	Value/Condition	How Applied	How Measured
LWD Frequency	Refer to **Table 4-9**	By stream width, stream order, Rosgen stream types	R1/R4 Method or Equivalent
Fish Passage	No human caused fish passage barriers that lead to undesirable fishery or aquatic life conditions	All reaches	Standard fish barrier approaches; expert biological opinions

SECTION 8.0
WATER QUALITY RESTORATION PLAN IMPLEMENTATION STRATEGY

An important component of this Water Quality Protection Plan will involve supporting and documenting the implementation efforts of the major land stewards in the basin. Achieving the targets and allocations set forth in this plan and as part of the TMDL development process will require a coordinated effort between land management agencies and other important stakeholders including the County Government and Conservation District, private landowners, and representatives from conservation, recreation and community groups with water quality interests in the Prospect Creek Watershed. Coordination of water quality protection in the Prospect Creek Watershed is being facilitated via the Green Mountain Conservation District (GMCD) in cooperation with Prospect Creek Watershed Council (PCWC) and technical advisory personnel that worked on development of this plan.

A watershed group such as GMCD and/or PCWC can encourage stakeholder involvement, and help provide for a feedback mechanism whereby stakeholders can discuss and document water quality improvements being made. The group can provide peer input to monitoring plans and analysis of results, and help identify new water quality concerns and methods to document impacts. The group can also compile reports, and serve as a repository for data being collected throughout the Prospect Creek Watershed and can also pursue funding and support for water quality implementation projects.

8.1 Introduction

The following section outlines a conceptual Water Quality and Habitat Restoration Plan (WQHRP) for the Prospect Creek Watershed. This WQHRP is intended to be an evolving document and will be updated as new information regarding resource conditions is collected. As described in preceding sections of this assessment, Prospect Creek has been subjected to a variety of direct and indirect natural and anthropogenic disturbances. Documented impacts to the channel date back to the middle to late 19th century when the valley was settled by early settlers. With this in mind, it is not realistic to expect a quick reversal from these impacts in the short-term. The proposed WQHRP attempts to restore water quality and habitat conditions by incorporating a watershed scale approach that first identifies the causes and sources of impairment, such as the approach applied in Sections 1.0 through 7.0, and secondly implements projects that will reduce the sources of sediment. It is imperative that the causes and sources of channel disequilibrium, specifically in mainstem Prospect Creek be addressed at the watershed scale. It is not unrealistic to assume that the components outlined in this WQHRP will require more than 10 years to fully implement, in addition to on-going monitoring (**Section 9.0**) and adaptive management strategies.

Restoration of water quality and habitat conditions in the Prospect Creek Watershed can be achieved through a diverse assortment of restoration actions and management strategies. The goals of the TMDL and WQHRP plan parallel restoration efforts currently underway and completed in the watershed. Sections 8.2.1 summarizes completed and ongoing restoration projects in the Prospect Creek Watershed. Additional strategies to achieve water quality goals

and TMDL targets are presented in **Sections 8.2.2**. Strategies specific to Prospect Creek mainstem and tributary streams are described in **Sections 8.3 and 8.4**.

Management or restoration strategies fall into two categories: 1) watershed-wide management activities to promote overall upland and stream health and 2) targeted strategies to address observed impairments primarily on mainstem Prospect Creek and major tributary streams. Each restoration strategy will need to be assessed on a site-specific basis to determine its feasibility with respect to site constraints, cost, environmental benefit, and stakeholder support. Restoration strategies will be prioritized based on benefit and feasibility. Implementation and effectiveness monitoring of the restoration strategies is outlined in **Section 9.0**. Monitoring and adaptive management, as described in **Sections 4.0, 6.0 and 9.0**, are critical to achieving and/or updating water quality goals and to the overall success of the restoration strategies.

8.2 Watershed-Wide Restoration Strategies

As demonstrated in **Sections 4.0**, Prospect Creek is currently functioning below geomorphic and biological potentials. This condition may also be occurring in one or more tributaries. Impairments described in **Section 4.0** and water quality restoration goals outlined in **Section 7.0** provide much of the basis for future water quality restoration strategies presented in this plan. Restoration strategies recently implemented by the Lolo National Forest are described and additional strategies, which apply across the Prospect Creek Watershed, are presented. Strategies specific to mainstem Prospect Creek and major tributary stream are presented in **Sections 8.3 and 8.4**.

In this section, water quality strategies for Prospect Creek focus on overall watershed improvements and related fish habitat improvements such as increasing pool frequency and large woody debris concentration. Strategies include reducing surface and substrate fines and/or maintaining low levels of surface fines and substrate fines, maintaining a diverse macroinvertebrate community, and maintaining fish passage where desirable. Overall, restoration strategies will also concentrate on improving habitat conditions and increasing bull trout spawning access and spawning redd conditions.

Recommendations for improving stream corridor conditions include passive and active restoration techniques applied at site-specific locations and at the reach scale. A number of potential watershed-wide restoration strategies have been identified. To varying degrees, these strategies can be applied to meet the goals of the WQHRP. They include: 1) forest management practices, 2) riparian management plans, 3) addressing roads and stream crossing problems, and 4) fish habitat improvement including fish passage barrier removal (if deemed desirable) and active and passive LWD recruitment.

8.2.1 Completed and Planned Watershed-Wide Prospect Creek Water Quality and Habitat Restoration Strategies

Since TMDL development began in the Prospect Creek watershed, there have been a number of activities that have been completed or designed that are consistent with the overall restoration

goals as outlined throughout this document. The following identifies some of those activities undertaken recently.

Crow Creek BPA Powerline Stream Restoration Project

The removal of valley bottom trees in order to install the BPA powerlines in the mid-1950s caused unstable stream conditions, bank erosion, poor fish habitat, and an altered migration corridor in a ½ mile section of Crow Creek. A cooperative project between the US Forest Service, Montana Fish, Wildlife and Parks, the Lower Clark Fork Watershed Group and Avista involved stabilizing stream banks, reconstructing meanders, reducing width to depth ratios where the channel was overwidened and constructing a single channel where channel braiding had occurred, shaping the channel, and replacing large woody materials. Wetland areas were also created as part of this project. Particular attention was placed on the revegetation plan. Low-growing species including alder and dogwood were incorporated into the design in order to naturally stabilize stream banks and floodplain areas. These low growing species would not disrupt the overhead powerlines in the area and provide a significant improvement over the previous condition.

Cooper Creek Watershed Culvert Replacements

Two sites containing undersized culverts within the Cooper Creek watershed were replaced with adequately sized bridges. Undersized culverts have a direct relationship to potential sediment loads, channel morphology disruption, and diminishing fish passage capability. Replacing culverts with open span bridges is the preferred option when economically feasible as it maintains the most natural flow and morphology conditions over varying flow conditions, and dramatically reduces the potential for failure and associated sediment loads.

Daisy Creek Stream Restoration Project

A tributary to Prospect Creek in the Lower Prospect HUC 6 watershed, in 2005 Daisy Creek had 1000 feet of stream relocation and 600 feet of stream restoration which included reshaping channel to natural pattern form and adding habitat structure. Two failing culverts were also removed along with ½ mile of trail relocation outside of the riparian area.

Forest Service Road Decommissioning and Timber Sales

Since 1993, the Prospect Creek watershed has seen multiple road decommissions with varying degrees of decommission intensity in East Fork Crow Creek, West Fork Crow Creek, Crow Creek, Cooper Creek, and Dry Creek. This work has included road obliteration; blading and revegetation of road surface; road closure; culvert removal; and resloping and recontouring. As vegetation recovers on decommissioned roads, it effectively reduces the sediment loads associated with forest roads and reduces the overall road density within each watershed.

Yellowstone Pipeline Reroutes

Since 1997, YPL has completed eight pipeline reroutes to move the pipeline away from Prospect Creek, into highway right-of-way. The construction phase of the project was completed in 2002 and involved rerouting or replacing approximately 10 miles of pipeline, abandoning in-place approximately 7 miles of pipeline and completion of 2.2 miles of pipeline removal. These efforts have helped reduce bank erosion associated with the pipeline where pipeline has been removed, and improve riparian corridor where pipeline has been abandoned in place.

8.2.2 Additional Watershed-Wide Prospect Creek Water Quality and Habitat Restoration Strategies

8.2.2.1 Forest Management Practices

In general, many of the most damaging forestry practices of the past, including riparian clear cutting, have been abandoned by the timber industry. In the Prospect Creek Watershed, timber sales are planned and laid out by the Lolo National Forest (LNF) on National Forest land as well as by individual lands owners on privately owned land.

Future management (harvest, road building, fuels treatments, etc.) will be conducted by all landowners according to Forestry Best Management Practices (BMPs) for Montana (MDNRC, 2002) and the Montana streamside management zone (SMZ) law (MDNRC, 2002a). Additionally, KNF will continue to comply with the Inland Native Fish Strategy (INFS) and Forest Plan standards. This includes road building and maintenance (also discussed below), as well as prescribed burning, forest thinning and timber harvest.

Compliance with the voluntary forestry BMPs, Soil and Water Conservation Practices handbook, and the SMZ law is a strategy to help achieve sediment- and habitat-related water quality goals, including meeting the sediment load allocation by preventing mass wasting, keeping forest management-related sediment from entering streams, and preventing excess fine sediment loading and potential pool filling. The Forest Service is mandated through a Memorandum of Understanding (MOU) with the Water Quality Bureau (now DEQ) to comply with SWCPs. Compliance will also help with improving habitat conditions by fostering LWD recruitment.

In particular, the Forest Service's mandatory compliance with SMZ law and the Lolo National Forest Plan Standards. (USFS, 1986) will help in meeting LWD targets in the upper watershed and will eventually help in meeting pool targets as well. Under both, vegetative buffers strips are required and will help achieve sediment-related water quality goals. The area of disturbance can be reduced through appropriate selection of harvesting systems (i.e., cable logging from roads on steep slopes rather than using tractors) and by reducing the number of roads needed. These also limit the amount of harvest that can occur within certain stream buffer distances. INFISH (1995) provides additional protective measures for streamside vegetation within the National Forest.

Forestry BMPs are particularly important for achieving sediment-related targets, allocations and the TMDL. Steep slopes and highly erodible soils have the potential to deliver high sediment loads to streams if bare mineral soil is exposed and inadequate erosion control applied. Since vegetative cover plays a critical role in preventing hillslope erosion, the management strategies address land use practices that have the potential to expose bare mineral soil in critical areas. The plan aims to decrease production and delivery of sediment from erosion-prone hillsides. The strategy to prevent or reduce erosion and sediment delivery in these areas is to implement best management practices (BMPs) when conducting forestry, grazing, and other land management activities.

Additional restoration strategies may include a voluntary program that requires that landowners be aware of unstable or erosion-prone areas when conducting activities. If activities in these

areas cannot be avoided, appropriate techniques should be used to minimize the extent of the disturbance, apply erosion control practices on disturbed soils.

Where disturbance occurs, forestry BMPs require that erosion be controlled with practices such as grass seeding and straw mulch application. Logging slash (tree limbs, etc.) is often placed on the ground in erosion prone areas to create ground cover and prevent erosion. Lastly, streamside buffers are retained to encourage deposition of any sediment prior to entering streams.

Additionally, tracking progress toward meeting targets and allocations is a high priority. Supplemental indicators such as ECA, water yield, peak flow increases, road density and road density in riparian areas, should be tracked to help evaluate potential water quality impacts (or lack thereof) from timber harvest activities in drainages where harvest occurs. This could be coordinated with tributary monitoring recommendations in **Section 9.0**. Implementation strategies for other harvest-related source categories like road sediment and culverts are addressed separately below because these impacts are also associated with other land use categories.

8.2.2.2 Riparian Management Plans

As development pressure increases along the banks of Prospect Creek, there is likely to be additional reduction in riparian vegetation and floodplain function if appropriate preventative measures are not taken. Additional reduction in and/or maintenance of currently low levels of riparian vegetation would lead to additional and/or continued channel instability, streambank erosion, increased stream temperatures, and probable increased loading of nutrients and sediment. Impacts from private land development, especially where a structure (buildings, pipelines, utility towers, etc.) is located adjacent to or on the bank of a stream can be harder to mitigate once they occur in comparison to many of the impacts associated with logging or other land use practices.

Many of the impacts associated with private land development are associated with roads and stream crossings. These impacts and potential solutions are discussed in the following sub-section (**8.2.2.3**).

The targets and allocations that apply to private land development tend to focus on riparian health and associated indicators of riparian health. Water quality protection includes avoiding bank erosion from human causes, improving riparian health and increasing canopy density, avoiding the need for riprap and other "stabilization" work, and avoiding placement of structures (buildings, pipelines, utility towers, etc.) in the floodplain or close to streambanks. Construction of structures such as houses, barns, roads, corrals, pipelines, and utility towers and lines within the zone of historical channel migration is of major concern since this can lead to an eventual need for hard riverbank stabilization to avoid the loss of structures as the river migrates laterally through the floodplain.

To meet the TMDL targets, TMDL allocations, and other restoration objectives and reduce water quality threats, especially as they relate to riparian removal and floodplain or streambank encroachment, the following actions are recommended:

- A comprehensive educational effort needs to be undertaken to stress the importance of riparian protection. Education can focus on grazing management practices, home and structure location consideration, and other factors applicable in the Prospect Creek Watershed.
- Additional floodplain and streambank protection regulations should be evaluated and updated to ensure protection of the resource. Stakeholders can work with the Planning Offices of Sanders County to help develop effective regulations that can be part of the County Growth Plans, Subdivision Regulations, or Floodplain regulations. It is important to note that these types of land use planning and regulatory decisions are made at the local (i.e. county) versus the State level.
- The effectiveness of voluntary versus regulatory measures could be tracked. This would include evaluating the effectiveness of county regulations aimed at protecting riparian and floodplain areas and streambanks. Updated aerial photographs, when available, should be analyzed to provide measures of impact indicators such as canopy cover or structures within a certain distance from a stream. Field assessments can also be performed, with landowner involvement, to further analyze the effectiveness of water quality measures particularly along mainstem Prospect Grave Creek. This information can then be used as a feedback mechanism to measure success and to help identify whether or not an increased focus is needed on regulatory versus voluntary protection measures regarding riparian, floodplain, and/or streambank protection.
- Land use indicators should be tracked to supplement water quality data in monitoring existing or potential water quality impacts. Riparian composition and density is one of the more critical land use indicators to monitor along mainstem Prospect Creek. This should include temperature monitoring as well as consideration of nutrient and sediment loading.

In addition to the above activities, the Green Mountain Conservation District will continue to provide oversight and protection of riparian resources and stream health through the 310 law.

8.2.2.3 Road Maintenance, Construction and Stream Crossings

Roads and stream crossing assessments in Prospect Creek Watershed need to be completed. LNF has completed partial assessments and removal or upgrades of some culverts in the watershed. LNF has also implemented road BMPs on approximately 7 miles of roads, with approximately 48 miles of roads undergoing some form of decommission as described in **Section 8.2.1**. Evaluation of the crossings and roads not assessed should include status of road BMPs and improvement needs, including removal of existing structures and sizing and installation of new structures, improving blading practices, and reconfiguring roadbeds and ditches as necessary to decrease sediment load to streams. Improvement needs should be prioritized and implemented.

Roads

Sediment from roads should be minimized to avoid excess fine sediment problems throughout the Prospect Creek Watershed. While sediment delivery from forest roads is typically highest in the first few years after construction, and declines rapidly thereafter, there are many opportunities for reducing sediment delivery from roads in the Prospect Creek Watershed. The plan promotes actions that will improve road conditions. In response, the following is a list of recommendations to help protect water quality and satisfy allocations:

1. The USFS should continue to prioritize sediment contributing road sections and stream crossings for upgrading and sediment load mitigation. Specific locations and methods of sediment reduction will be left up to the judgment of the land managers, although some specific observations of potential sediment reduction locations are provided in **Section 8.4.** This process should be pursued as a coordinated effort so that total road sediment reductions can be tracked in a consistent manner.
2. Assessments should occur for roads within watersheds that have experienced recent timber management operations and recent restoration activities. The information gathered during these assessments will allow timely feedback to land managers about the impact their activities could have on water quality and achievement of TMDL targets and allocations, and to monitor the effectiveness of restoration implementation. This feedback mechanism is intended to keep sediment load calculations current and avoid impacts that go undetected for an extended period.
3. An effort should be made to work with small landowners and county representatives to identify significant sediment contributions from private (non-industrial) and county roads and to help develop methods to mitigate the sediment load. This assistance could also include identification of funding sources for BMP implementation where appropriate.
4. Existing and potential future private landowners should be provided information on how to design roads and mitigate impacts associated with road sediment delivery. This could include support from realtors, USFS, PCWC, GMCD, USFWS and other landowners planning to subdivide to incorporate this information up front to potential new home owners/builders in the watershed.
5. This plan also encourages the careful design and placement of new roads in subdivisions as well as routine maintenance of all subdivision roads to reduce sediment loading to streams. The goal is to apply the same or similar BMP standards to county and other private roads as are applied to roads built for timber harvest purposes.

Culverts

New or replaced culverts or culverts on upgraded roads throughout the watershed should be sized for a 25, 50 or 100-year flood event with preference toward the 100-year flood design when possible. The 25-year event design is consistent with state BMPs, although in areas of high existing culvert density, new culverts should be designed for a 50 to 100-year event instead of a 25-year event. Other design considerations should include avoiding negative impacts to local fish habitat from stream constriction and avoiding floodplain restrictions by using bottomless arches or other appropriate designs. Where appropriate, culverts should also be designed and installed to prevent fish passage restrictions.

The Lolo National Forest is currently pursuing the above goals for new and upgraded culverts by ensuring passage of a 100-year flood event to meet their native fish protection requirements. The Forest Service has also performed a fish passage inventory for culverts located on fish bearing streams throughout the watershed.

An analysis of existing culverts and the potential for culvert failure should be undertaken in conjunction with ongoing Forest Service efforts. Each crossing could be assigned a priority for restoration based on the risk of failure, the amount of sediment loading from a failure, and the level of disturbance associated with culvert replacement or upgrade.

Detailed on-the-ground assessments would need to be completed as part of the prioritization. GMCD/PCWC technical advisory personnel could assist with prioritization and also assist small landowners with resolution to problems on private property, including potential funding assistance via 319 or other water quality grants. Fish passage (discussed below) would also need to be considered as an additional component to the prioritization process. Input from biologists will be critical to determine the relative value of providing fish passage in each situation.

Some specific observations of potential culvert removal and/or upgrades locations are provided in **Section 8.4**.

Bridges

Additional information should be gathered to identify locations where bridge crossings are contributing to negative stream impacts, especially sediment loading conditions and localized negative impacts to aquatic life. This study should identify all bridge crossings along with potential impacts, solutions, and cost considerations. A decision can then be made regarding any bridge mitigation projects to pursue.

Some specific observations of potential bridge upgrade locations are provided in **Section 8.3.**

Other Stream Crossing Considerations

The following are additional requirements and considerations to help mitigate impacts from stream crossings and further protect aquatic life.

- In accordance with State Law, Green Mountain Conservation District and Montana Fish, Wildlife and Parks, will continue to work to protect fish and aquatic habitat through 310 and 124 permits.
- A watershed or stakeholder group can help provide technical solutions, when requested, to 310 related issues and concerns.

Fish Passage Barrier Removal

Identification of fish passage barriers on existing roads is an important goal. According to Forest Service fish passage analysis results reported in **Appendix H**, of the stream crossings surveyed, twenty-eight (28) fish passage barriers on fish bearing streams exist in the Prospect Creek watershed. Other stream crossing on private roads should be assessed for fish passage. All identified fish-passage barriers should be evaluated, as described above, to determine the relative value of providing fish passage in each situation. Existing laws and standards prohibit the

creation of new fish habitat barriers. Exceptions may be made under special circumstances, for example when it is deemed desirable to isolate pure populations of fish.

8.3 Prospect Creek Mainstem-Specific Restoration Strategies

As described in **Sections 4.0 and 5.0** and the Phase I assessment document (RDG, 2004), past and recent investigations on Prospect Creek indicate the main stem is impaired for sediment and aquatic habitat, particularly below Cooper Gulch. Indicators of impairment include low pool frequency, deficient LWD, an overly wide, shallow, and straight stream, and poor riparian vegetation. Water quality restoration strategies for mainstem Prospect Creek should focus on increasing pool frequency, reducing width-to-depth ratios, increasing sinuosity, maintaining diverse macroinvertebrate and fish communities, and improving riparian vegetation/temperature. Water quality restoration strategies also focus on keeping percent fines low.

Recommendations for improving habitat conditions in lower Prospect Creek include passive and active restoration techniques applied at site-specific locations and at the reach scale. A number of potential treatments have been identified (RDG, 2004). To varying degrees, these treatments can be applied to meet the goals of the WQHRP. Possible treatments include: 1) site revegetation (floodplains, rip-rap slopes, streambanks), 2) channel reconstruction, 3) bank stabilization, 4) meander reactivation, 5) fish habitat improvement, and 6) discrete sediment source mitigations. Possible treatment types and project areas for mainstem Prospect Creek are described in greater detail in the Phase I assessment document (RDG, 2004). In addition, the watershed-wide strategies described in **Section 8.2.2** which are applicable to mainstem Prospect Creek include: forest and riparian management practices, addressing roads maintenance, construction and stream crossing problems, and additional fish habitat improvement.

Restoration treatments recommended for mainstem Prospect Creek focus on Reaches 2, 3, and 4, from the confluence of Cooper Gulch downstream to Clear Creek. **Appendix B** of the Phase I assessment document (RDG, 2004) provides specific locations for recommended restoration treatments.

8.3.1 Revegetation

Revegetation treatments offer the most passive method to establishing long-term channel stability, riparian succession, and habitat diversity. Stream banks supporting mature, native vegetation are among the most stable reach on Prospect Creek. The primary advantage of riparian plantings is that installation can be accomplished with minimum impact to the stream channel, existing vegetation, and private property. In addition to providing shade and cover for aquatic species, riparian plantings can develop root masses that penetrate deep into the soils, increasing bank resilience to erosion. Other advantages include cost effectiveness and the range of applications offered by new revegetation technologies.

The most significant disadvantage to vegetative treatments is that results are not immediate and time is required to establish a mature gallery (i.e. multi-storied) forest that provides the benefits described previously. As such, revegetation is not an appropriate treatment for areas that are subject to high shear stress, perched too high relative to the water table (i.e. aggraded), or

vulnerable to grazing impacts. The most appropriate applications for revegetation on Prospect Creek are floodplains, streambanks, and the adjacent floodway riparian zone. Revegetation treatments would coincide with channel shaping and channel reconstruction techniques further described in **Section 8.3.3**. In order for any revegetation effort to be successful on Prospect Creek, the proper channel dimensions must be established to ensure the plan form pattern is maintained for a sufficient period of time allowing the plants to mature.

8.3.2 Bank Stabilization

Bank stabilization using natural channel design techniques can provide both bank stability and habitat potential. The primary recommended structures are large woody debris jams. These natural arrays can be constructed to emulate historical debris assemblages that were introduced to the channel by the adjacent red cedar and cottonwood dominated riparian community types. When used in concert, woody debris jams and straight log vanes can benefit the stream and fishery by improving bank stability, reducing bank erosion rates, adding protection to fill slopes and/or embankments, reducing near-bank shear stress, and enhancing aquatic habitat and lateral channel margin complexity.

Other bank stabilization techniques such as riprap, gabions and concrete retaining walls were considered, but eliminated from further consideration because they do not accommodate natural stream form and function, tend to be more expensive, and do not meet the habitat objectives of this project. In areas of high concern or increased shear stress against the stream banks, such as near bridge crossings or other constrictions, rock riprap could be used along with woody debris composites to provide protection for infrastructure. In these areas, aesthetics and habitat will be sacrificed for increased durability during flood events.

It is important to clarify that streambanks associated with stream channel reconstruction activities would have bank stabilization techniques applied.

8.3.3 Stream Channel Shaping / Reconstruction

Channel shaping and reconstruction would be focused in areas of extreme channel braiding. Treatments would include floodway revegetation and bank stabilization as described in the preceding sub-sections. A majority of the excessive bedload present in the mainstem Prospect Creek is derived from bank and terrace erosion. Effective channel restoration along segments of Prospect Creek, working from upstream to downstream, is imperative to reduce these sources to a degree where the channel can maintain equilibrium with the flow and sediment produced in the watershed. Channel reconstruction involves the realignment of the channel bed along with channel shaping, bank stabilization, and revegetation. Channel reconstruction is the most optimal method to restore the river to its historical condition. With channel reconstruction, it is possible to restore the potential meander pattern of a river and adjust the bed elevation so that the floodplain and active channel are hydrologically reconnected. As described in **Section 3.0** of this assessment, segments of the mainstem appear to be hydrologically disconnected or entrenched due to excessive cross-sectional area that conveys flows in excess of the bankfull discharge. Channel reconstruction would include reconstructing a stable, single-threaded primary channel sized to accommodate the estimated bankfull series, and partially filling existing braided

channels to floodplain elevation. Portions of the braided channel area would be maintained as backwater refuge for fish and wetland development. Fill material would be extensively revegetated with native plants.

Perhaps one of the most beneficial advantages associated with reconstructing braided channel segments to single-threaded systems would be a reduction in the rate of lateral channel migration, thereby reducing maintenance costs and continual efforts on behalf of utility companies and YPL to protect floodway infrastructure. In the vicinity of power poles and gas line infrastructure, the channel alignment could be strategically designed to minimize shear stress and the potential for lateral channel extension. Additional techniques to protect floodway infrastructure would be to establish a channel alignment that permits construction of both a bankfull floodplain and/or low terrace feature adjacent to the power pole or utility.

Other advantages with complete channel reconstruction include improved sediment transport competency, complex and diverse aquatic habitat creation, an increase in floodway capacity and flood relief, and long-term bank stability.

8.3.4 Meander Reactivation

Two types of meanders were identified for potential meander reactivation. The first type includes those disconnected during construction of County Road No. 7. The second type includes those disconnected via channel instabilities and avulsive processes.

Preliminary examination suggests that there are numerous opportunities to reactivate disconnected meanders. Depending on the condition of riparian vegetation and ability to reconnect the historical floodplain to the active channel, the cost to reactivate meanders could be substantially less than total channel reconstruction.

8.3.5 Fish Habitat Improvement

Fish habitat improvement would be incorporated in all restoration applications. However, there are segments along the mainstem that are functioning at their physical potential and could benefit from added fish habitat complexity to increase biological complexity. The structures to be included with channel shaping and stream channel reconstruction will also increase fish habitat quality and availability.

In addition, other treatments described above and below will also benefit fish habitat. Addressing revegetation will likely reduce stream temperatures and thus improve fish habitat. Similarly, channel shaping and reconstruction will increase sediment transport capacity, and increase pool frequency, which will also improve fish habitat.

8.3.6 Discrete Sediment Source Mitigation

An issue of concern related to discrete sediment sources is highway maintenance practices such as salting, sanding, drainage, and snow plowing (**Section 5.0** of this document, and RDG, 2004). Currently, snow plowing and drainage practices allow salt and sand to be pushed or conveyed

directly down embankments and/or riprap fillslopes into the river. Through the implementation of some basic solutions, these impacts may be significantly mitigated.

One of the primary methods for reducing the impact of highway maintenance practices is to concentrate stormwater runoff and snowmelt in a gutter and convey it to a catchment, floodplain terrace, or wetland area where it can infiltrate slowly into the ground. In situations where there is no floodplain, the flow may need to be conveyed in a storm drain to the opposite side of the highway (away from the river). In addition, some areas may require snow storage areas beyond the highway shoulder so that snow is not plowed directly into the river.

An alternative treatment, and a likely more feasible alternative, would include construction of narrow bankfull floodplains that would effectively separate the channel from the active roadway and filllslopes. Bankfull floodplains are typically stabilized with a combination of native material structures such as rootwad composites and debris jams, and vegetation transplants. The new bankfull floodplain can be constructed in an area where the stream is over-widened, thereby improving sediment and flood conveyance. In other areas, constructing a bankfull floodplain may necessitate shifting the channel away from the road by an equal width or constructing or modifying the floodplain on the opposite bank. The benefits of incorporating this technique in select areas of the mainstem Prospect Creek and tributaries include:

1. Increased flood carrying capacity,
2. Reduced stress on banks, road fillslopes, retaining walls, and riprap, and
3. Improved water quality, fish and riparian habitats.

8.4 Prospect Creek Tributary-Specific Restoration Strategies

8.4.1 Clear Creek

Water quality restoration strategies in Clear Creek should focus on reducing high bedload supply, decreasing width-to-depth ratios, increasing pool frequency and deficient LWD, and increasing sinuosity.

In-stream restoration work should focus on the over-widened D stream type channel segments. Natural channel design techniques that re-establish the historical channel pattern would improve flood flow conveyance, sediment transport, and fish passage and habitat. Constructing stable large woody debris jams would improve sediment retention and fish habitat creation. Additionally, placement of such structures at strategic locations would protect the valley bottom road network during high flow events.

Riparian vegetation in the upper watershed is functioning near historical potential. Riparian communities in the middle and lower watershed reflect past timber harvest and current beaver activity. Re-establishing cottonwoods and willow to these portions of the watershed would improve the long-term recovery of the historical riparian community. Cottonwood and willow colonization will be necessary to maintain bank stability, provide channel shading, and delivery large woody debris to Clear Creek.

High road densities in the watershed and the close proximity of forest roads to stream corridors are causes of fine sediment delivery to the Clear Creek. Implementing road BMPs should be a priority to decrease fine sediment delivery to the stream.

Tempering utility corridor maintenance practices will also improve channel stability and riparian diversity. Relocating utility lines outside of the riparian zone would improve channel function and reduce the need for regularly treating riparian vegetation that resets riparian recovery.

Table 8-1 summarizes priority restoration activities for the Clear Creek drainage. As noted, approximately 4-5 miles of channel restoration is recommended for stream reaches located on private and USFS lands, with focus on restoring the proper channel dimensions, pattern, and profile. Riparian revegetation would be a primary goal with emphasis on vegetation succession, structure and composition.

Table 8-1. Restoration Priorities in the Clear Creek Watershed

• Natural channel design (upper 1 mile PVT; lower 3 - 4 miles FS) o Establish appropriate channel dimension, pattern & profile o Rigorous revegetation & weed treatment
• Culvert replacement – upgrades
• ATM - Road closure and/or decommissioning
• Road BMPs & maintenance practices
• Trail BMPs & maintenance in upper watershed

8.4.2 Dry Creek

Water quality restoration strategies in Dry Creek should focus on reducing the supply and delivery of coarse and fine sediment to the stream network, decreasing width-to-depth ratios, increasing pool frequency and LWD, and possible increasing sinuosity in the lower reaches.

Riparian harvest and the proximity of the road network to Dry Creek are two areas of concern for Dry Creek. B stream types throughout the drainage are stable and capable of efficiently transporting the available sediment load. The riparian communities on private land holdings, especially in the lower drainage, are functioning below their historical potential. A lack of road and stream crossing BMPs throughout the watershed are a concern, but offer substantial opportunity to reduce the quantity of fine sediment delivery to the stream.

Road and trail BMPs are recommended for FSR 352 to address the undersized bridge that confines the stream flow, creating a bed scour condition. Rock grade control structures are recommended for improving flow conveyance and sediment transport while stabilizing the channel bed. Increasing the culvert size at the East Fork Dry Creek crossing near the Knox Creek trailhead would improve flood flow conveyance and sediment transport. Other intermittent and ephemeral crossings should be improved for proper drainage.

FSR 352 blading practices during summer 2003 were inappropriate and created an additional sediment source in the Dry Creek drainage. Road maintenance should abide by BMPs and improve road drainage rather than impair it. Stabilizing crib walls that currently maintain FSR

352 in the lower canyon reach may need to be shored up to improve their integrity. Not addressing the condition of these structures may result in hill slope failure and mass wasting of the slope.

The Dry Creek culvert at the Gold Rush Creek campground should be upgraded to the bankfull channel width. The existing undersized culvert is negatively affecting channel stability and riparian condition.

Riparian vegetation in the upper watershed is functioning near historical potential. Riparian communities in the middle and lower watershed reflect past timber harvest. Re-establishing cottonwoods and willow to these portions of the watershed would improve the long-term recovery of the historical riparian community. Cottonwood and willow colonization will be necessary to maintain bank stability, provide channel shading, and deliver large woody debris to Dry Creek.

Table 8-2 summarizes priority restoration activities for the Dry Creek drainage.

Table 8-2. Restoration Priorities in the Dry Creek Watershed

• Road BMPs & maintenance practices
• Riparian revegetation in lower reaches
• In-channel grade control in lower reaches
• Culvert replacement – upgrades
• Campground relocation
• Trail BMPs & maintenance in upper watershed
• ATM - Road closure and/or decommissioning

8.4.3 Wilkes Creek

In general, Wilkes Creek is a properly functioning stream. However, the condition of the National Forest portion of lower Wilkes Creek is less than optimal, particularly in comparison to Upper Wilkes Creek. This portion of lower Wilkes appears to be recovering from past natural and human-caused impacts. Restoration opportunities in the watershed exist, but are of relatively low priority.

Restoration opportunities include working with the Baxter family to remove washed out culverts at several attempted stream crossings, replacing the bridge in Section 33 with a structure that conveys at a minimum, bankfull flows, implementing BMPs on the entire road system, and decommissioning or closing upland Roads 1026, 18794, and 2142. Of particular concern is removal or upgrade of culverts on Table Top and Coyote Gulches (tributaries to Prospect Creek).

Table 8-3 summarizes priority restoration activities for the Wilkes Creek drainage.

Table 8-3. Restoration Priorities in the Wilkes Creek Watershed

• Headcut stabilization in lower reaches
• Removal of washed out CMPs
• Table Top & Coyote CMPs
• Bridge replacement - upgrade
• Riparian revegetation
• Other road work

8.4.4 Cooper Gulch

Restoration strategies in Cooper Gulch should focus on reducing coarse and fine sediment, reducing width-to-depth ratios, increasing pool frequency and LWD.

The most obvious opportunities involve road and recreation maintenance. All stream crossings need to be replaced with appropriately sized structures. Design and specifications for these structures have been completed by USFS. BMPs need to be applied to the entire length of FSR 7623. Culverts need to be upgraded on FSR 877 including those on Spokane and Chipmunk Creeks. The Spokane Creek culvert is at a high risk of failure. The undetermined road in lower Cooper Gulch could be obliterated, at least past the stream crossing, including bridge removal and bank re-contouring. Barriers would need to be placed to prevent fording while revegetation from bridge removal is established.

Lower Spokane Creek through the dispersed campsite is over-widened. Along with upgrading the Spokane Creek crossing near the confluence with Cooper Gulch, Spokane Creek could be narrowed through the campsite. Bank stabilization, revegetation, and access barriers would be needed. The dispersed campsite at Chipmunk Creek has similar needs.

Location and management of the road and power line in Cooper Gulch, and their impacts to the aquatic resources needs to be evaluated. Many options and opportunities exist to reduce or remove these impacts, including minimizing vegetation clearing and pruning. Travel management needs throughout the watershed should be assessed including the need for many of the power line access roads that are now vegetated with saplings and shrubs.

Several opportunities exist to relocate sections of the road and/or power line. Relocating sections of road that are immediately adjacent to the stream to up-slope position away from the stream would reduce riparian impacts, although power line access necessitates roads in the valley bottom. In addition to relocating the stream-side road segments, sections of the power line could be realigned to follow the road corridor more closely to further minimize riparian impacts. The Northwestern Energy power line could also be relocated from Cooper Gulch to accompany the BPA power line in Crow Creek. This would minimize riparian impacts from these utilities to one watershed instead of two. Road 7623 could then be decommissioned or converted to a trail.

Whether road and power line relocation, in part or whole, is considered feasible, restoration of the stream channel, floodplain, aquatic habitat and riparian vegetation in Cooper Gulch is one of the highest priorities in the Prospect Creek watershed because of the critical low-flow refugia

and reproductive rearing Cooper Gulch offers to westslope cutthroat trout and bull trout in summer months. Continued influence from power line maintenance and the road prohibits Cooper Gulch from recovering on its own. Restoration efforts should be focused in several reaches (**Table 8-4**).

Natural channel design should be implemented in the braided, aggraded, and straightened reaches to accommodate flows capable of transporting bedload while maintaining natural stream characteristics including aquatic habitat. Bank stabilization and revegetation measures will be critical to maintaining this stability. Fish habitat throughout the straightened and aggraded reaches needs to be enhanced. Large woody debris should be actively recruited from non-riparian sources.

Table 8-4. Restoration Opportunities in the Cooper Gulch Drainage

Reach	Restoration Needs and Considerations
7	Needs are minimal, but may be required to tie into new pattern for Reach 6
6	Reestablish single thread channel in the aggraded sections under the power line; new channel should be away from eroding valley slope
4	Stabilize banks; install structures to divert energy from banks with power poles
3	Reestablish single thread channel in the aggraded sections under the power line; reestablish meanders in straightened sections along the road
2	Establish a bankfull bench on the left bank at the base of the terrace. This reach will likely guide the pattern and dimension for restoration in Reach 1.
1	Re-naturalize from a straight confined riffle, although feasibility may be low due to degree of entrenchment from former floodplain

8.4.5 Crow Creek

Restoration strategies in Crow Creek should focus on reducing fine sediment, particularly from road surface erosion, increasing pool frequency and LWD and possibly increasing sinuosity in mainstem Crow Creek.

Location and management of the BPA power line should be evaluated because of its impacts to aquatic resources. Power line relocation in Crow Creek is likely less feasible than in Cooper Creek because of the size of the transmission towers and lines. Modifying maintenance activities may help reduce impact to aquatics resources. The most obvious opportunities involve road and recreation maintenance. **Table 8-5** summarizes priority restoration activities for the Crow Creek watershed.

Table 8-5. Restoration Priorities in the Crow Creek Watershed

• Address power line location, clearing, maintenance

• Natural channel design (upper mainstem)
  ○ Establish appropriate channel dimension, pattern & profile
  ○ Stabilize headcuts
  ○ Rigorous revegetation & weed treatment

• Culvert replacement – upgrades
• Bridge upgrade & realignment
• County Highway No. 471 culvert – upgrade, alignment, grade control
• Road & recreation BMPs & maintenance practices
• ATM - Road closure and/or decommissioning

Travel management needs throughout the watershed should be assessed to determine which roads can be decommissioned. Reducing road density and restoring the hydrologic response of the watershed may facilitate recovery of degraded stream channels, especially in the mainstem. BMPs should be applied to all system roads. Undetermined roads in lower Crow Creek could be obliterated at least beyond stream access, including culvert removal, bank re-contouring, and revegetation. Some rehabilitation is needed along lower Crow Creek associated with dispersed campsites and stream fords.

The bridge on FSR 877 below the confluence of the forks should be replaced with an adequately sized and appropriately aligned structure.

The County Highway No. 471 culvert should be replaced with an adequately sized structure capable of passing flow and sediment. Crossing alignment should be adjusted with the new structure to better facilitate channel pattern upstream and downstream of the crossing. Grade control structures may be required to prevent headcut progression from lowered base level in mainstem Prospect.

Restoration of the stream channel, floodplain, aquatic habitat and riparian vegetation in Crow Creek is another of the highest priorities (along with Cooper Gulch) in the Prospect Creek. Continued influence from power line maintenance and altered hydrologic response in the watershed prohibits Crow Creek from re-stabilizing on its own.

Natural channel design should be implemented in the upper half of the mainstem to accommodate flows capable of transporting bedload while maintaining natural stream characteristics including aquatic habitat. Entrenchment of this reach is not yet great enough to prohibit reactivation of the most recent floodplain. Crow Creek could be restored to the old meandering channel or the existing channel could be lengthened with meanders, and slope reduced with an undulating bedform. Bank stabilization and revegetation measures will be critical to maintaining this stability. Fish habitat throughout the reach needs to be enhanced (none currently exists). Large woody debris should be actively recruited from non-riparian sources.

8.4.6 Cox Gulch

Several restoration opportunities exist in Cox Gulch but are of relatively low priority. Opportunities include: paving the section of FSR 876 that passes through the mine processing facility to eliminate airborne particulate pollution, implementing BMPs on FSR 876, including surface material, drainage, and upgraded culverts. Maintenance of headwater culvert removals to meet BMP standards is also suggested. Another restoration option to road upgrades would be removal of remaining culverts, and decommissioning of the headwater road system and valley bottom road. Riparian areas may be protected from future subdivision and residential development of mine in-holdings by proactive collaboration between the stakeholders and land owners.

8.4.7 Evans Gulch

There is potential for bank restoration at dispersed camp sites along lower Evans Gulch on the left terrace and at trail-stream crossings. These opportunities are low priorities.

Of moderate priority is the restoration opportunities involved in reducing the in-channel sediment sources. Although the YPL reroute occurred recently, a re-naturalized channel in the lower Evans Gulch above and below County Highway No. 471 may help prevent further headcut progression. This would include removal of the large rip-rap currently used as channel substrate above the County Highway No. 471 crossing, reshaping the channel, increasing channel length and installing grade control structures. An adequately sized crossing structure at County Highway No. 471 would be desirable.

Also of moderate priority is addressing the in-channel sediment source on the West Fork. To limit the source of sediment aggrading at the confluence, upgrading the West Fork culvert should be prioritized, or the culvert removed and the road decommissioned. With either of these options, it may be necessary to install grade control structures to prevent headcut progression from channel scour at the culvert outlet.

8.4.8 Glidden Gulch

The Glidden Gulch trail-stream crossings could be rehabilitated and more formal trail-stream crossing structures installed to prevent continued resource damage. BMPs should be applied to trail segments approaching stream crossings. Undersized culverts could be upgraded and BMPs applied to FSR 7615 and FSR 7627. Alternatively, the portion of FSR 7615 beyond Trail 404, and the FSR 7627 system could be decommissioned.

8.4.9 Twentyfour Mile Creek

Predominantly reference conditions in the Twentyfour Mile Creek watershed limit the need for restoration. Opportunities that do exist are relatively low priority, including: increasing the size of the County Highway 7 crossing so that it may adequately pass the water and bedload at high flows, relocating the lower portion of trail and re-contouring the point of capture, and repairing the trailhead parking area and access road.

SECTION 9.0
WATER QUALITY AND HABITAT MONITORING PLAN

9.1 Introduction

Monitoring is an important component of watershed restoration, a requirement of TMDL development, and the foundation of the adaptive management approach. This monitoring plan for the Prospect Creek Watershed is a multi-strategy effort designed to address specific TMDL goals such as attainment of restoration targets and load allocations. Participation of a number of planning partners including a variety of state and federal agencies, stakeholders, and additional parties provides a key element to this plan that increases its value by providing a multi-disciplinary approach and valuable local knowledge.

The principles of adaptive management provide a foundation for the monitoring plan presented here. A well-designed monitoring plan facilitates the adaptive approach by providing feedback on the effectiveness of restoration activities, the relative contributions of sediment from various sources, and feasibility of attaining targets. Within this adaptive framework, monitoring results provide the technical justification to modify restoration strategies, numeric targets, or load allocations when appropriate. Similarly, lessons learned from monitoring results may be applied in various watersheds to facilitate diverse watershed planning efforts.

To assess overall progress toward meeting the restoration targets identified in **Section 4.0**, this monitoring plan includes examination of a combination of physical stream conditions (both channel and riparian) and biological community measures. The monitoring strategy is focused on implementation monitoring including some additional assessment and watershed characterization activities to help facilitate implementation. Implementation monitoring is required to assess the effectiveness of specific future restoration activities, to assess whether compliance with water quality standards has been obtained by evaluating progress toward meeting restoration targets, and to assist with any adaptive management decisions as needed. Implementation monitoring to assess progress toward meeting restoration targets is required by TMDL rules (§§75-5-703(7) & (9)), and is also an integral component of the implicit margin of safety incorporated in the sediment TMDLs.

Implementation monitoring focused on compliance with TMDL targets will be done at least once every five years as defined by the TMDL regulations, with additional monitoring performed as needed to ensure timely evaluation of completed restoration activities. DEQ is responsible for the implementation monitoring focused on tracking TMDL and water quality restoration progress, although other entities may perform significant aspects of the monitoring and it is expected that the overall effort will be closely coordinated with the Lolo National Forest, Montana Fish, Wildlife and Parks, Avista, and Prospect Creek Watershed Council and Green Mountain Conservation District.

In many cases, more sampling may be desirable to better measure progress. Because some target development is based on local reference conditions, monitoring may also need to include measurements in reference streams to ensure an appropriate baseline comparison condition. Changing watershed conditions in reference streams could justify modification to target or

supplemental indicator values. Significant environmental factors such as drought, floods, or fires can affect both reference and impaired stream conditions throughout a watershed, and may be important factors in determining target achievability. This is particularly true for the McNeil Core and other fine sediment sampling where yearly sampling on many streams helps establish overall watershed trends and can help evaluate relative impacts from natural events.

9.2 Monitoring of TMDL Targets

As defined by Montana State Law (§§75-5-703(7) & (9)), DEQ is required to evaluate progress toward meeting TMDL goals and satisfying water quality standards associated with beneficial use support at least every five years. Implementation monitoring is, therefore, necessary to assess progress toward meeting the targets developed in **Section 4.0**. Where targets are not being met, additional implementation monitoring may be necessary. This additional implementation monitoring may evaluate the status of supplemental indicators and the progress toward meeting allocations, and could result in modifications to the targets as part of adaptive management. Implementation monitoring is also an integral component of the implicit margin of safety incorporated in the TMDLs developed in this restoration plan. Although DEQ is responsible for aspects of implementation monitoring, other agencies and entities often perform significant aspects of the monitoring.

Table 9-1 identifies monitoring and assessment recommendations for all Prospect Creek stream reaches. The focus of **Table 9-1** is on both primary and supporting targets. The goal is to obtain samples or perform monitoring in representative locations as well as locations where potential impairment conditions would most likely exist. All monitoring efforts are to be done using standard DEQ sampling and analyses protocols where applicable or sampling and analyses protocols approved by DEQ. Based on further stakeholder input and DEQ approval, some of the **Table 9-1** details such as monitoring locations or methodologies may be modified. The monitoring is applied to all Prospect Creek segments and tributaries with focus on those targets or reference values that were not met or were lacking in data.

DEQ efforts to evaluate progress toward meeting TMDL goals and satisfying water quality standards does not need to always include incorporating monitoring of all target and indicators. In some situations, the DEQ may determine that not enough progress or opportunity for stream recovery has been made to warrant evaluations of all targets and/or indicators.

On the other hand, it may be desirable to obtain data prior to the five year evaluation for parameters lacking baseline values. These include macroinvertebrate sample results throughout many areas of the watershed and percent fines values. Also, it may be desirable to obtain routine data for pool frequency, residual pool depth, and LWD linkages to help develop and incorporate trend information and expand on applicable fish habitat knowledge.

Table 9-1. Monitoring Locations and Parameters to Help Evaluate Target Compliance and Beneficial Use Support

Waterbody	Parameter(s)	Desired Location(s)	Sample Method	Sample Period
Prospect Creek and tributaries	Percent surface fines	Representative riffle and/or pool tail locations in Prospect Creek main stem and tributaries with focus on areas where data is desirable to supplement a lack of McNeil Core sample data	Wolman Pebble Count	Low flow
Prospect Creek and tributaries	Percent surface fines	Representative pool tailout locations in Prospect Creek main stem and tributaries with focus on areas where data is desirable to supplement a lack of McNeil Core sample data	Grid Toss or Equivalent (e.g. viewing bucket)	Low flow
Prospect Creek and tributaries	Percent substrate fines	Upper Prospect Creek and in tributaries in locations of bull trout and/or cutthroat trout spawning; pebble counts may be acceptable alternative	McNeil Core	Low flow
Prospect Creek and tributaries	Pools frequency	Same as for 2003 and other recent assessment work or agreed upon representative sampling of stream reaches. Incorporate any linkages to LWD.	Longitudinal Profile and R1/R4; consider using multiple methods for comparison to reference reach data sets	Low flow
Prospect Creek and tributaries	Width-to-depth	Prospect Creek and tributaries, particularly C and D Reaches	Standard Bankfull Cross Section Measures	Low flow
Prospect Creek and tributaries	Sinuosity	Prospect Creek and tributaries, particularly C and D Reaches	Standard aerial assessment	NA
Prospect Creek and tributaries	RSI	Prospect Creek and tributaries, particularly C and D Reaches	Method established by Kappesser	Low flow
Prospect Creek and tributaries	Large Woody Debris	Same as for 2003 assessments work or agreed upon representative sampling of stream reaches	R1/R4 Method or Equivalent	Low flow
Prospect Creek and tributaries	Riparian Vegetation	Multiple representative reaches throughout Prospect Creek and major tributaries: Dry, Clear, Cooper, Crow	% density; shade with densitometer;	Leaf-on
Prospect Creek and tributaries	Macro-invertebrate assemblages	Two to four representative riffle locations in Prospect Creek main stem and in tributary reaches. Focus additional sampling in areas of higher percent surface fines in riffles	Standard DEQ protocol	Low flow, summer to early fall; between June 21 to September 21 per existing DEQ protocol
Prospect Creek and tributaries	Bull trout redd counts	Continuation of ongoing FWP effort and locations; additional tributaries if appropriate	Existing procedure used by Fish Wildlife and Parks	Late summer to early fall

Table 9-1. Monitoring Locations and Parameters to Help Evaluate Target Compliance and Beneficial Use Support

Waterbody	Parameter(s)	Desired Location(s)	Sample Method	Sample Period
Prospect Creek and tributaries	Residual Pool Depth; Possibly Pool Length or other measures	Same as for 2003 assessments work or agreed upon representative sampling of stream reaches	R1/R4 Methods or equivalent	Low flow

9.3 Monitoring of TMDL Allocations, Supporting Targets, and Land Use Indicators

As discussed above, implementation monitoring can include assessment of both target compliance and efforts to successfully pursue activities that would reflect progress toward achieving allocations. This monitoring may focus on:

- Forest and private roads and implementation of BMPs;
- Riparian health along the mainstem and BMP implementation;
- The effectiveness of BMPs and a range of water quality protection activities associated with future harvest or forest management activities;
- Land use or land modification data such as potentially significant changes in ECA (from timber harvest and natural events), peak flow, and/or road density; and
- Bank erosion loading determinations or other measurement approaches along mainstem Prospect Creek.

These types of monitoring activities should be done in cooperation with landowners including private landowners and Lolo National Forest representatives.

9.4 Project Effectiveness Monitoring

An additional type of monitoring involves efforts to assess the effectiveness of specific restoration or water quality improvement activities. All water quality projects should have some form of monitoring to assess overall effectiveness. In some situations, the monitoring can provide feedback for future projects or feedback on maintenance requirements. This monitoring can take on many forms, and can be as simple as before and after photos.

As described in **Section 8.0,** several restoration activities have recently been implemented the Prospect Creek Watershed. These activities should be monitored for implementation and effectiveness. Restoration activities to be monitored include: active channel restoration, passive restoration (natural recovery), revegetation, pipeline re-routes (including old and new locations) and riparian and grazing management plan effectiveness. Monitoring results should be used to refine future restoration activities and to guide adaptive management of ongoing land-uses and attainment of water quality improvement goals.

9.5 Additional Monitoring and Assessment

During this TMDL and water quality and habitat restoration improvement planning efforts, a number of supplemental monitoring activities emerged as priorities. These priorities include efforts to track progress toward satisfying non-pollutant related restoration objectives, such as fish passage, not otherwise addressed by the TMDL target monitoring discussed above. These and other monitoring recommendations are listed below.

- Culverts and other potential fish passage barriers should continue to be evaluated for passage capabilities as has been assessed by the Lolo National Forest. New culvert and crossing installations or replacements should be conducted with fish passage in mind and should be monitored for implementation and effectiveness. Culvert size and slope should allow for fish passage.
- A better understanding of fish communities and fish habitat use would provide greater insight into beneficial use support requirements in the watershed and could help focus target compliance monitoring. Fisheries investigations may include population estimates, redd counts, and fish movements through the basin. Fisheries evaluations can assist in assessing the effectiveness of restoration activities as part of an adaptive approach.
- As identified in **Section 9.3** above, predicted water yield and peak flows should be tracked in drainages with significant harvest. Also, a method to identify and track harvest in sensitive areas could be useful for identifying potential impacts, including success of all forestry BMPs, and various management practices aimed at water quality protection.
- Additional monitoring of Chlorophyll a and related nutrient parameters in Dry Creek should be conducted throughout the summer months to further investigate the Chlorophyll a pollutant listing for TMDL development.
- It would be useful to track the transport rate of large woody debris. In particular, this could help determine the residence time of LWD from natural sources versus from logging activities. Research has shown that large woody debris in harvested watersheds consists of typically shorter logs (logging remnants) that are more mobile at lower flows. Woody debris in wilderness watersheds was observed to consist of generally longer more fully intact wood that is more stable at lower flows and only mobile at higher flows. Increased mobility translated to reduced residence time, and therefore less stable pools. In addition, pool volume associated with smaller, sawed off wood was reduced. Residence time of large woody debris in wilderness/non-harvested watersheds was much greater than in harvested watersheds and resulted in large, more frequent, and more stable pools (Ferree, 1999).
- Efforts in other TMDL areas are underway to link pebble count results to McNeil core data. Additional pebble counts and possibly additional grid toss data should be pursued in conjunction with McNeil core sampling to help with this overall effort since pebble count data and grid toss results can apply as targets to indicate potential spawning impacts where McNeil Core data is lacking.
- Temperature data, using a similar method as reported in **Appendix I**, should continue to be collected in to supplement existing limited data.
- Cross section benchmarks could be added to help evaluate overall stream stability over time.

- Conditions in the YPL corridor should be closely monitored to ensure stream stability at existing, re-route, and abandonment locations. Channel morphology parameters, stream bank stability, and riparian vegetation and stream temperature are all issues of concerns in such locations. Trends should be evaluated and management plans modified as necessary if stream stability, function, habitat and temperature appear to be compromised.
- Develop monitoring strategy associated with analyzing potential increase in riparian area as it relates to canopy cover from mature tree species adjacent to roads, power lines, or other land uses (residential development).
- Continue monitoring by MDT of TSS other water quality parameters associated with sand and salt application and snow plowing.

REFERENCES

Daly, C. and G.Taylor. 1998. Montana Average Annual Precipitation, 1961-1990. (PRISM). Corvallis, OR: Oregon State University http://nris.mt.gov/nsdi/nris/shape/precip.zip. http://nris.state.mt.us/nsdi/nris/precip.html

Elliot, W. J., R. B. Foltz, and M. D. Remboldt. 1994. Predicting Sedimentation from Roads at Stream Crossings with the WEPP Model. Paper No. 947511. Presented at the 1994 ASAE International Winter Meeting. St. Joseph, MI: ASAE.

Elliot, W. J., R. B. Foltz, and C. H. Luce. 1995. Validation of the Water Erosion Prediction Project (WEPP) Model for Low-Volume Forest Roads. Proceedings of the Sixth International Conference on Low-Volume Roads. Washington, DC: Transportation Research Board.

Elliot, W.J., D.E. Hall, S.R.Graves, and D.L. Scheele. 1999. XDRAIN Cross Drain Spacing – Sediment Yield Program Version 2.0 Technical Documentation. http://forest.moscowfsl.wsu.edu/fswepp/docs/xdrain2doc.html

Ferree, Jonathan D. 1999. Geomorphic Change over a Twenty-Year Interval in Harvested and Unharvested Watershed of the Oregon Coast Range. Master's Thesis. Laramie, WY: University of Wyoming.

(INFISH), Inland Native Fish Strategy. 1995. Environmental Assessment: Decision Notice and Finding of No Significant Impact. Interim Strategies for Managing Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana and Portions of Nevada. [Place of publication unknown]: U.S. Department of Agriculture, Forest Service, Intermountain, Northern, and Pacific Northwest Regions.

Kappesser, Gary.B. 2002. A Riffle Stability Index to Evaluate Sediment Loading to Streams. *Journal of the American Water Resources Association* 38-4: 1069-1081.

Montana Bull Trout Restoration Team. 2000. Restoration Plan for Bull Trout in the Clark Fork River Basin and Kootenai River Basin Montana. Helena, Montana: Montana Bull Trout Restoration Team.

Montana Department of Environmental Quality. 2004. Circular WQB-7: Montana Numeric Water Quality Standards. Helena, MT: Montana Department of Environmental Quality.

Montana Department of Environmental Quality. 2004a. Sufficient Credible Data/Beneficial Use Determination (SCD/BUD) Documentation. Helena, MT: Montana Department of Environmental Quality (MDEQ).

Montana Department of Environmental Quality. 2006. Standard Operating Procedure Water Quality Assessment Process and Methods. Helena, MT: DEQ. http://deq.mt.gov/wqinfo/QAProgram/SOP%20WQPBWQM-001.pdf

Montana Department of Environmental Quality. 2006. Total Maximum Daily Loads for Metals in Prospect Creek Watershed. Helena, MT: Montana Department of Environmental Quality.

Montana Department of Natural Resources and Conservation. 2002. Best Management Practices (BMPs) for Forestry in Montana. Missoula, Montana: DNRC.

Montana Department of Natural Resources and Conservation. 2002a. Streamside Management Zone Law (Montana Code Annotated Section 7-5-300). Missoula, Montana: DNRC. http://data.opi.state.mt.us/bills/mca_toc/77_5_3.htm.

Moran, S. 2004. Fish Abundance Studies: Fisheries Survey of the Prospect Creek Drainage, Montana-2003. Noxon, MT: Fish Passage/Native Salmonid Program, Appendix C.

National Oceanic and Atmospheric Administration. 2000. Climatography of the United States No. 81. Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1971 – 2000. Asheville, NC: National Climatic Data Center.

Omang, R.J., 1992. Analysis of the Magnitude and Frequency of Floods and the Peak-Flow Gaging Network in Montana. *U.S. Geological Survey Water-Resources Investigations Report*: 92-4048

Parrett, C., and D.R. Johnson. 2004. Methods for Estimating Flood Frequency in Montana Based on Data through Water Year 1998. Water-Resources Investigations Report 03-4308. Washington, D.C.: USGS.

Rosgen, D.L. 2001. A Practical Method of Computing Streambank Erosion Rate. *Proceedings of the Seventh Federal Interagency Sedimentation Conference.* Vol. 2, pp. II - 9-15, March 25-29, 2001, Reno, NV.

River Design Group. 2004. Final Prospect Creek Watershed Assessment and Water Quality Restoration Plan. Whitefish, Montana: River Design Group.

Roedel, M. D. 1999. Montana Animal Species of Special Concern. (Unpublished List). Helena, MT: Montana Natural Heritage Program.

Rosgen, Dave L. 1996. Applied River Morphology. Lakewood, CO: Wildland Hydrology.

Stimson, E. 2004. Personal Communication. Email correspondence from Eric Stimson to Amy Beussink. September 8, 2004.

Suttle, Kenwyn, Mary Power, Jonathan Levine, Camille McNeely. 2004. How Fine Sediment in Riverbeds Impairs Growth and Survival of Juvenile Salmon. *Ecological Applications.* 14(4):969-974.

U.S. Environmental Protection Agency. 1999. Protocol for Developing Sediment TMDLs. Office of Water. EPA 841-B-99-004.4503 F. Washington DC: U.S. EPA.

U.S. Fish and Wildlife Service. 2002. Criteria Established for the Lake Koocanusa Core Area are Currently Being Met by the Grave Creek and Wigwam River Bull Trout Spawning Populations. Washington, D.C.: U.S. Fish and Wildlife Service.

U.S. Forest Service. 1986. The Lolo National Forest Plan. Final Environmental Impact Statement. Missoula, MT: Lolo National Forest.

U.S. Forest Service. 1988. Lolo National Forest Land System Inventory. Missoula, MT: U.S. Forest Service, Lolo National Forest.

U.S. Forest Service. 1991. WATSED Water & Sediment Yields. USDA Forest Service Region 1 and Montana Cumulative Watershed Effects Cooperative. Missoula, MT: U.S. Forest Service, Lolo National Forest.

U.S. Forest Service. 1997. Clear Creek Stream Restoration Needs Assessment: Report Prepared for the Clear Creek Environmental Assessment by the Riparian Revegetation Task Group. Missoula, MT: U.S. Forest Service, Lolo National Forest.

U.S. Forest Service. 1988. Lolo National Forest Land System Inventory. Missoula, MT: .U.S. Forest Service, Lolo National Forest.

U.S. Forest Service. 2000. Section 7 Consultation Watershed Baseline:Lower Clark Fork River, Montana. Libby, MT: U.S. Forest Service, Kootenai National Forest.

Washington Forest Practices Board. 2001. Board Manual. Section 11. Standard Methodology for Conducting Watershed Analysis. http://www.dnr.wa.gov/forestpractices/board/manual.

Woessner, W.W. and M. Shapley. 1984. The Effects of U.S. Antimony's Disposal Ponds on an Alluvial Aquifer and Prospect Creek, Western Montana. Missoula, MT: Joint Water Resources Research Center.

APPENDIX A
HARVEST AND WATER YIELD ANALYSIS SUMMARY

This section includes the results of spatial analysis conducted for the Prospect Creek watershed to analyze timber harvest and road building activities that could potentially affect the hydrology and runoff regime of the watershed. The information provided within this appendix provides additional insight into the current morphology and habitat conditions throughout the watershed. It also provides a reference to compare future harvest activities and outcomes against. Two sets of analyses are included: harvest activity analysis summary and water yield analysis. The analysis period is 1940 through 2003.

Harvest Analysis Summary

Vegetation communities in the Prospect Creek watershed have experienced several changes related to natural events and human activities. Logging of Lower Clark Fork River tributaries began in the late 1800s with the removal of accessible cedars and other species useful for building materials. Cedar stumps in the Clear Creek and Wilkes Creek sub-watersheds, and mainstem Prospect Creek, attest to the size of the mature cedars that once shaded the streams, contributed woody debris, and maintained bank integrity. Although some areas have experienced cedar recolonization, other reaches are now populated by Douglas fir and spruce. While these species provide several of the benefits attributed to cedars, the smaller conifers offer reduced channel shading, channel complexity, and bank stability.

Spatial analyses were conducted to describe the recorded harvest activity that has occurred during the twentieth century. Data used included the USFS TSMRS (Timber Stand Management Recording System) and a GIS layer of stand polygons, also provided by the Lolo National Forest. The data and results reflect harvest activity that has occurred primarily on National Forest which represents approximately 94% of the total watershed. Similar data for timber harvest on private land is not available, and the results presented below do not therefore included harvest activity that has occurred on privately owned land.

TSMRS records acres treated per stand. Stands are typically delineated by a silviculturist using air photo interpretation. A stand is typically a group of trees with similar characteristics in species composition, age and structure. According the USFS timber management handbook (USFS, 2004) a stand is defined as:

"A contiguous group of trees sufficiently uniform in age class distribution, composition, and structure, and growing on a site of sufficiently uniform quality, to be a distinguishable unit, such as mixed, pure, even-aged, and uneven-aged stands. A stand is the fundamental unit of silvicultural reporting and record keeping."

Stand size is highly variable. Stands in the Prospect Creek TMDL Planning Area (TPA) range in size from less than 1 acre to almost 500 acres. Recorded harvest activities in the Prospect Creek TPA through 2003 range in size from 5 acres to 169 acres.

TSMRS records the number of acres (based on slope length) treated within a stand. TSMRS does not record the location of activities within a stand. The number of treated acres based on slope length recorded in TSMRS was used to summarize harvest activities. Comparing the slope-length based treated acres to the total number of acres in a watershed based on planar-area calculations may result in an overestimate of the percent of the watershed treated. Accuracy and completeness of TSMRS database is another limitation. Analyses were conducted acknowledging these assumptions and limitations.

Table A-1 provides a list of the TSMRS activity codes included in this analysis. Activity acreages reflect multiple stand entries if a stand was entered more than once within the analysis period. Activities with accomplishment year 0 were planned activities that had not yet been completed as of this analysis in 2003.

Approximately 18,304 acres (16%) of the watershed have been harvested at least once (**Table A-2**); roughly the equivalent of the entire Clear Creek sub-watershed area. Of this, a little over 8,865 acres (8%) of the watershed was harvested in stands that are in or adjacent to the riparian corridor (**Table A-3**). A riparian-linked stand is a stand that has at least a part of the stand within the 300-foot riparian buffer. Harvest activity may not have occurred in the portion of the stand that is within the riparian buffer. Spatial distribution of activities below the stand level (i.e. within a stand) cannot be determined because, as described above, the minimum mapping unit of the TSMRS database is the stand.

Tables A-1 through A-3 and Figures A-1 through A-6 provide additional harvest summary statistics by year and watershed.

Table A-1. TSMRS Activity Codes Included in Prospect Creek Harvest Analysis

TSMRS Activity Code	TSMRS Activity Description
4111	Clearcut – Patch
4113	Clearcut – Stand
4114	Clearcut – with Reserves
4121	Shelterwood Preparatory Cut
4122	Seed Tree Preparatory Cut
4131	Shelterwood Seed Cut
4132	Seed Tree Seed Cut
4133	Shelterwood Seed Cut with Reserves
4134	Seed Tree Seed Cut with Reserves
4141	Shelterwood Removal Cut
4146	Shelterwood Final Cut
4148	Shelterwood Final Cut with Reserves
4151	Single Tree Selection Cut
4152	Group Selection Cut
4210	Improvements
4211	Liberation Cutting
4220	Thinning
4230	Sanitation Salvage
4231	Mortality Cut (Salvage)

4232	Sanitation

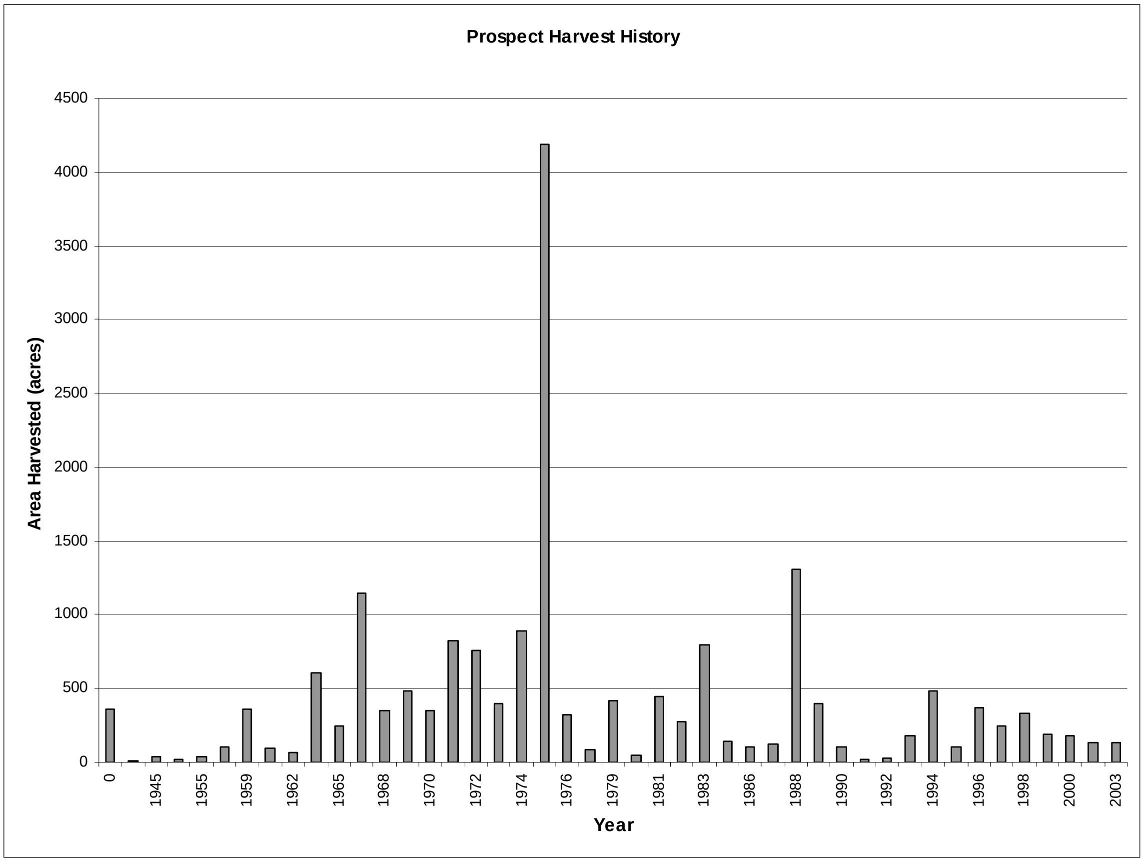


Figure A-1. Recorded Timber Harvest Activity in all Stands on National Forest in the Prospect Creek Watershed by Year

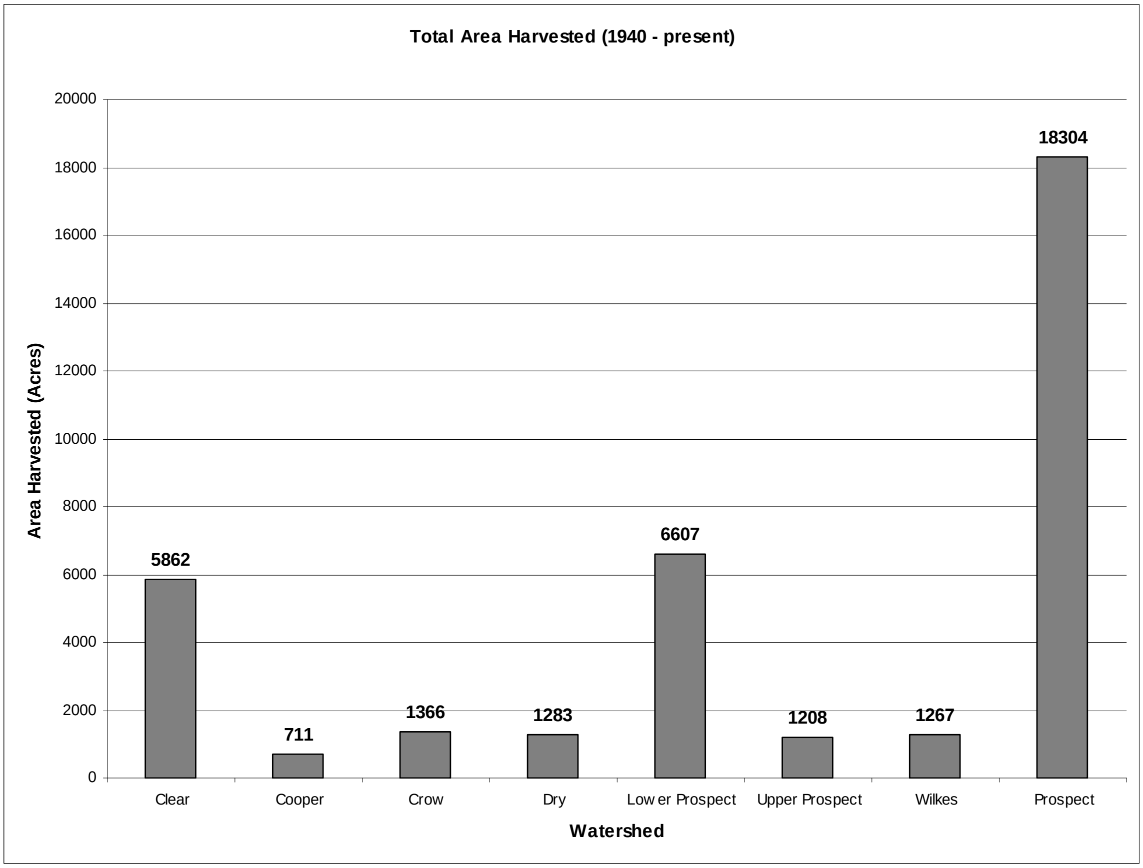


Figure A-2. Recorded Timber Harvest Activity in all Stands on National Forest in the Prospect Creek Watershed by HUC 6

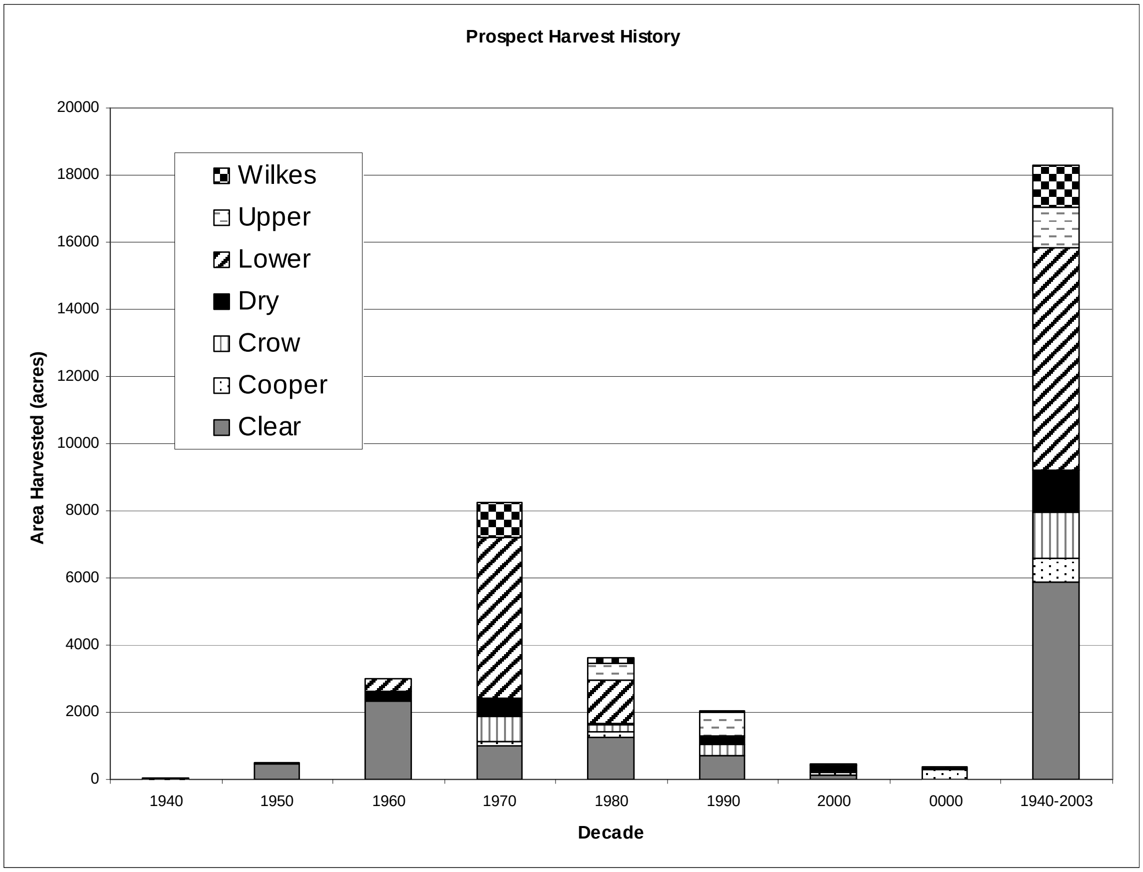


Figure A-3. Recorded Timber Harvest Activity in all Stands on National Forest in the Prospect Creek Watershed by Decade and by HUC 6

Table A-2. TSMRS Recorded Timber Harvest Activity in all Stands on National Forest in the Prospect Creek Watershed by Decade and by HUC 6

Area Harvested (Acres)	**1940**	**1950**	**1960**	**1970**	**1980**	**1990**	**2000**	**0000**	**1940-2003**	**Total Area in Sub-Watershed (Acres)**
Clear	0	479	2315	994	1257	694	123	0	5862	18304
Cooper	0	0	16	132	167	19	69	308	711	10112
Crow	0	0	0	732	196	340	64	34	1366	9472
Dry	0	0	312	556	55	188	172	0	1283	22912
Lower Prospect	48	39	359	4798	1273	61	12	17	6607	25792
Upper Prospect	0	0	0	0	495	713	0	0	1208	18944
Wilkes	0	0	0	1034	200	33	0	0	1267	10112
Total	**48**	**518**	**3002**	**8246**	**3643**	**2048**	**440**	**359**	**18304**	**115648**

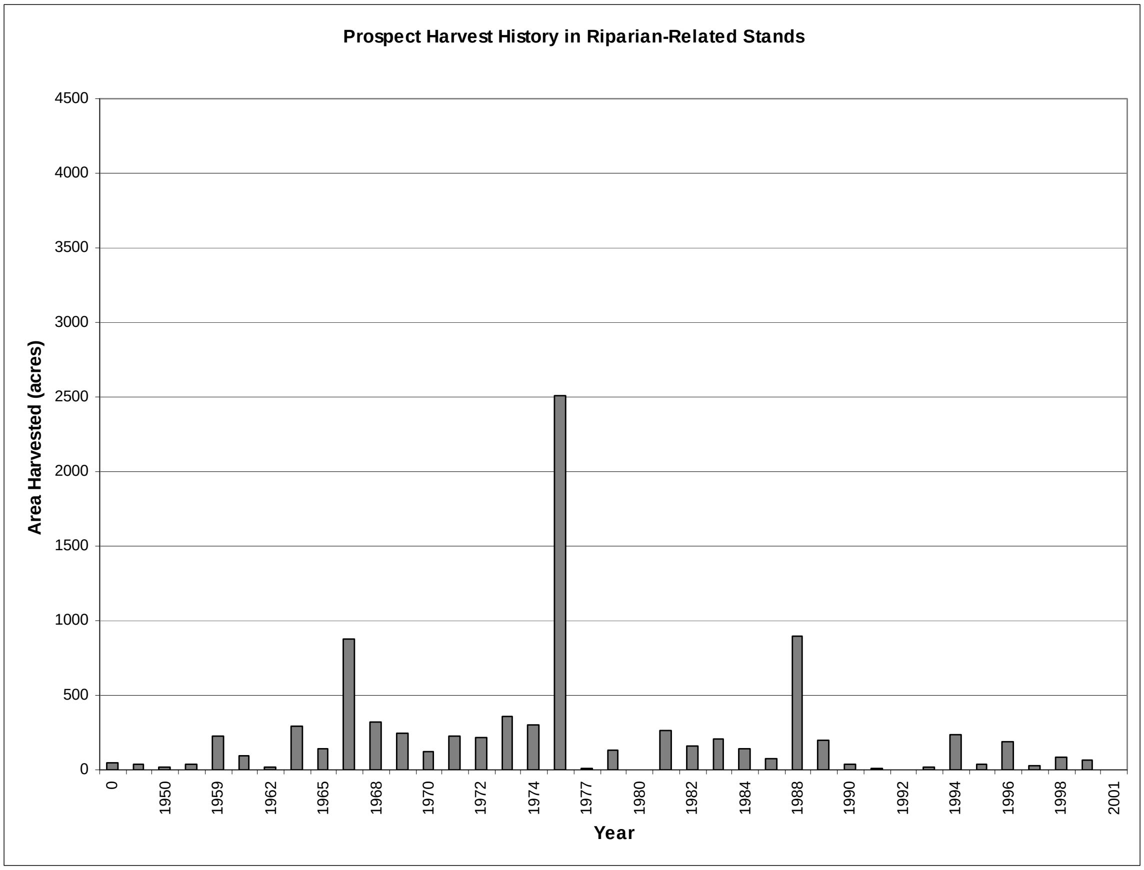


Figure A-4. Recorded Timber Harvest Activity in Riparian-Related Stands on National Forest in the Prospect Creek Watershed by Year

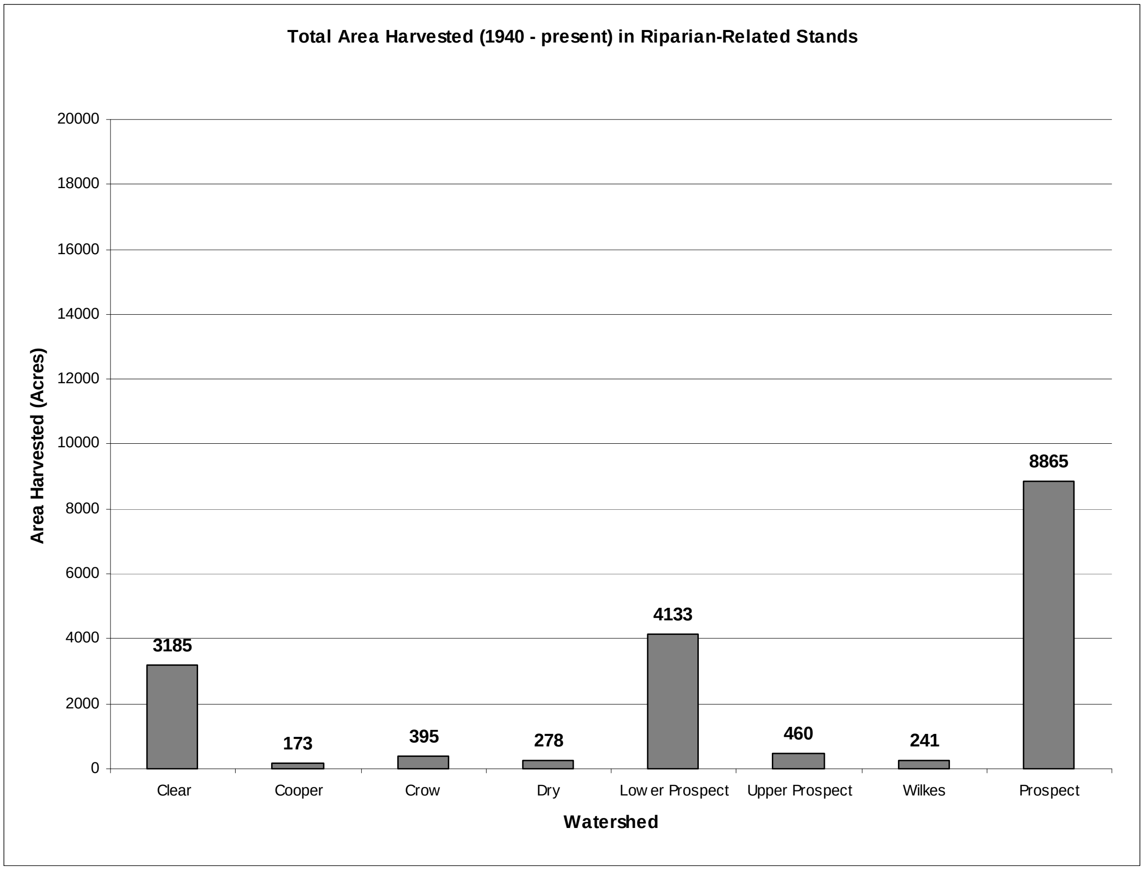


Figure A-5. Recorded Timber Harvest Activity in Riparian-Related Stands on National Forest in the Prospect Creek Watershed by HUC 6

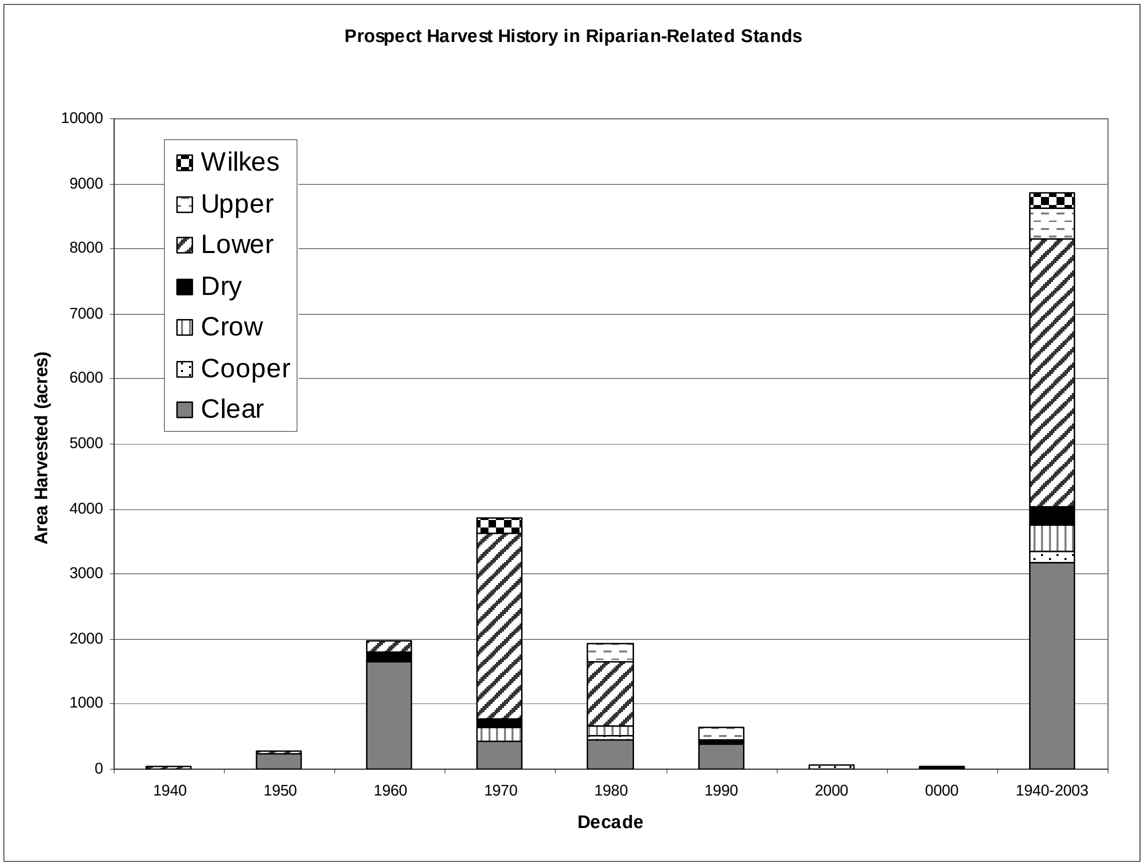


Figure A-6. Recorded Timber Harvest Activity in Riparian-Related Stands on National Forest in the Prospect Creek Watershed by Decade and by HUC 6

Table A-3: TSMRS Recorded Timber Harvest Activity (Acres*) in Riparian-Related Stands on National Forest in the Prospect Creek Watershed by Decade and by HUC 6

Area Harvested (Acres)	1940	1950	1960	1970	1980	1990	2000	0000	1940-2003	Total Area in Sub-Watershed (Acres+)
Clear	0	246	1657	435	453	394	0	0	3185	18304
Cooper	0	0	16	0	63	0	69	25	173	10112
Crow	0	0	0	204	147	18	4	22	395	9472
Dry	0	0	137	129	2	10	0	0	278	22912
Lower Prospect	39	39	169	2865	988	33	0	0	4133	25792
Upper Prospect	0	0	0	0	274	186	0	0	460	18944
Wilkes	0	0	0	235	6	0	0	0	241	10112
Total	**39**	**285**	**1979**	**3868**	**1933**	**641**	**73**	**47**	**8865**	**115648**

* Accomplishment acres recorded in TSMRS based on slope-length area.
\+ Acres based on planar calculations from GIS layer of HUC 6 watershed boundaries.

Water Yield Analysis

The impact of increased water yield on sediment transport depends on both the sediment availability as well as the temporal distribution of the additional water on the flow hydrograph.

Data derived from closely monitored, harvested watersheds characterized by spring snowmelt runoff have shown that the flow augmentation tends to be concentrated on the rising limb and peak of that spring snowmelt runoff event (Troendle et al., 2001). An increase in stream flow during the snowmelt period can result in a significant increase in sediment transport capacity, as spring runoff conditions commonly constitute the channel forming discharge, characterized by active sediment transport and channel adjustment (Andrews and Nankervis, 1995).

If sediment is conveyed to the stream network, the increased sediment transport capacity caused by an increase in peak flows will result in an increased delivery of sediment to Prospect Creek. Alternatively, if sediment is not available for transport, increased transport energy will result in sediment sourcing downstream from the channel perimeter due to bank and bed scour (Troendle et al., 2001). Therefore, the most effective means of preventing significantly increased water yield and associated sediment production and delivery is to increase or maintain a given amount of vegetative cover.

The effects of vegetation removal from road building, timber harvest and fire on water yield is analyzed based on Equivalent Clearcut Areas (ECA) modeling. The analysis included harvest activity recorded in the USFS TSMRS as well as consideration of vegetation removed for roads. Harvest and other activity on private land and National Forest harvest activity not recorded in TSMRS were not included. The TSMRS activity codes considered in this analysis are included in **Table A-1.**

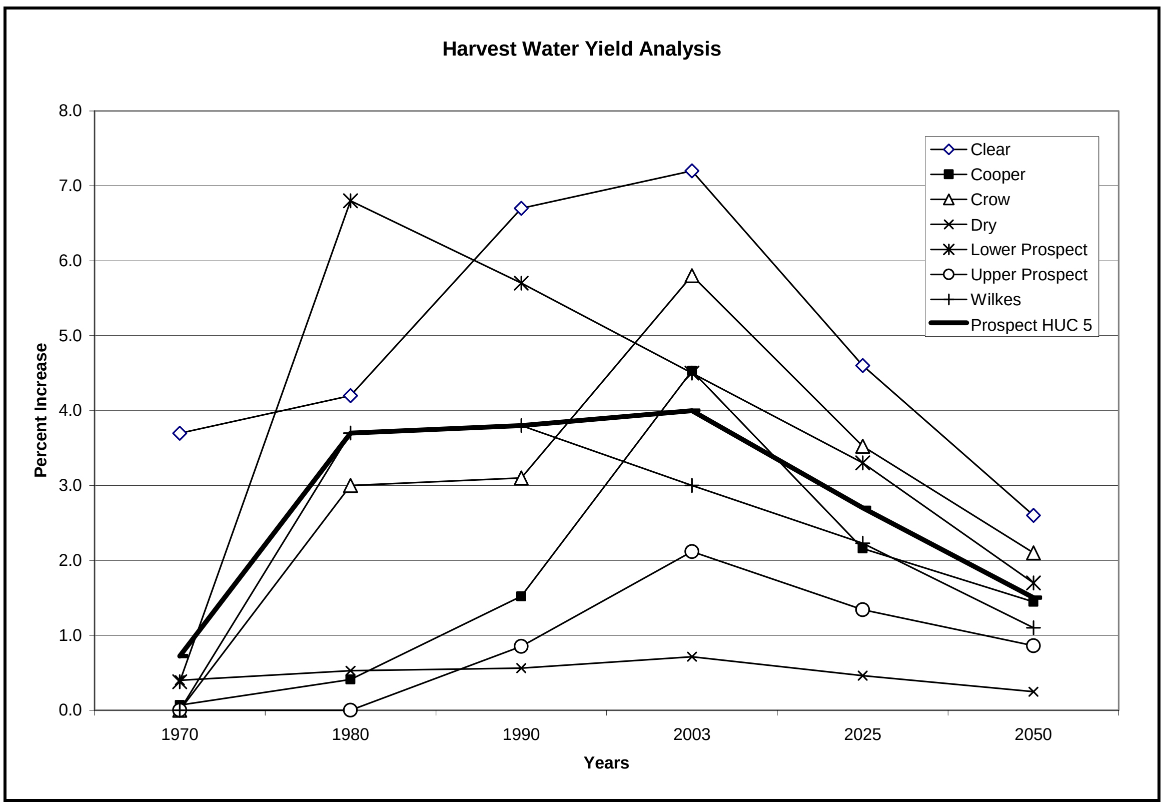


Figure A-7. Modeled Water Yield Increase (ECA Method) from Recorded Timber Harvest Activity on National Forest in the Prospect Creek Watershed by Decade and by HUC 6

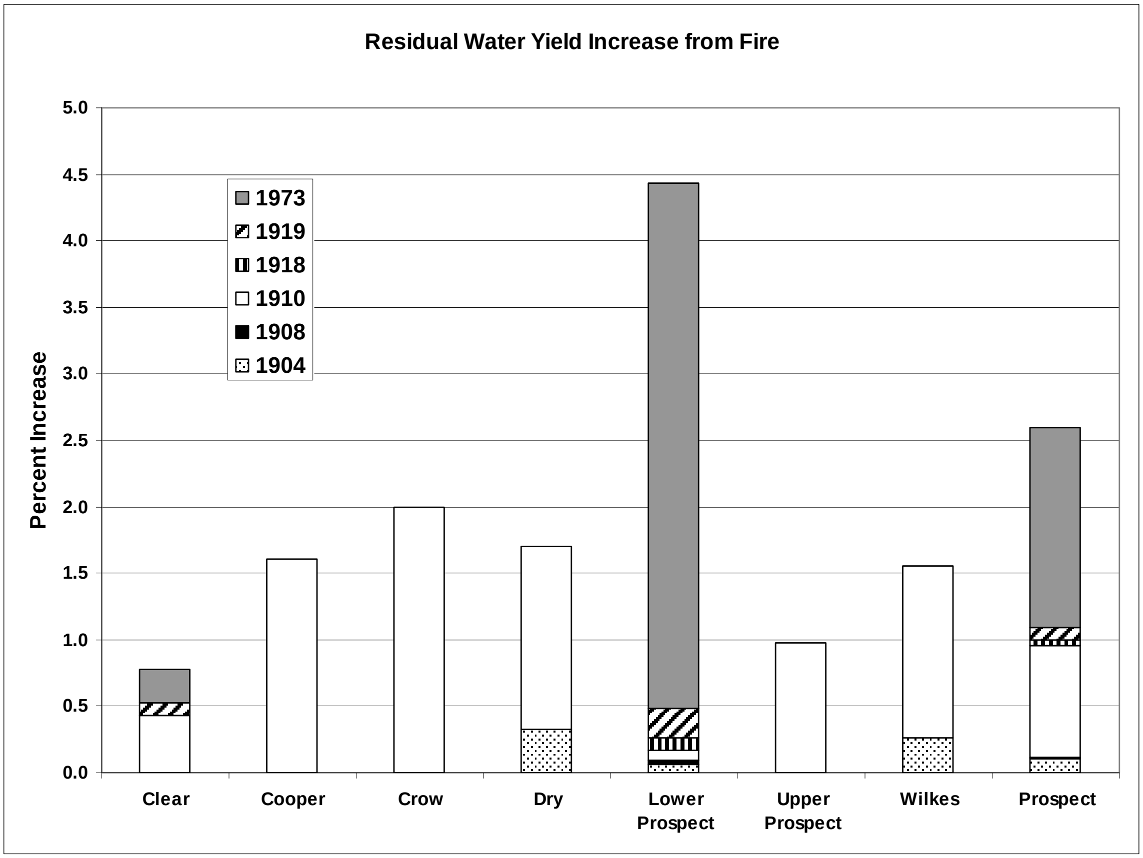


Figure A-8. Modeled Residual Water Yield Increase (ECA Method) from Recorded Fires in the Prospect Creek Watershed by HUC 6

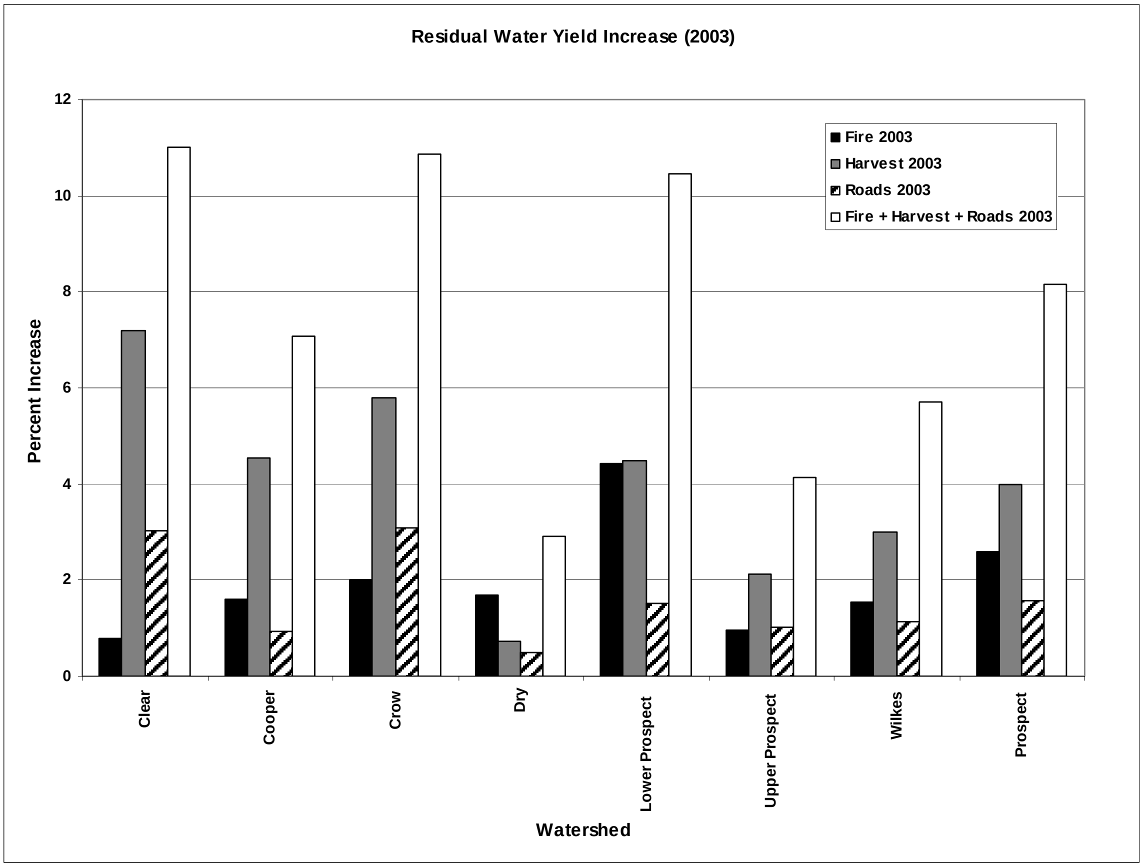


Figure A-9. Modeled Residual Water Yield Increase (ECA Method) from Recorded Roads, Fire, and Timber Harvest Activity in the Prospect Creek Watershed by HUC 6

References

Andrews, E. D. and J. M. Nankervis. 1995. Effective Discharge and the Design of Channel Maintenance Flows for Gravel-Bed Rivers: Natural and Anthropogenic Influences in Fluvial Geomorphology. *Natural and Anthropogenic Influences in Fluvial Geomorphology*. Geophysical Monograph (89): 151-164.

Troendle, C.A., D.L. Rosgen, S. Ryan, L. Porth, and J. Nankervis. 2001.Developing a "Reference" Sediment Transport Relationship. Presented at the Wildland Hydrology 7th Federal Interagency Sediment Conference, Vol. 2, pp. II, March 24-29, 2001 in Reno, Nev.

U.S. Forest Service. 2004. Forest Service Manual. FSM – 2400. Silvicultural Practices, Page 14. Washington, D.C.: U.S. Department of Agriculture.

APPENDIX B
ROADS, UTILITY CORRIDOR, AND PRIVATE LAND USE ANALYSIS SUMMARY

This appendix includes a description and analysis of roads and utility corridors and private land uses within stream buffer zones in the Prospect Creek watershed. The roads description and analysis includes road length stratified by ownership and type of road, the number of road-stream crossings by land ownership, road density and stream length with roads within stream buffer zones. Utility corridors, private land uses, and County Highway 471 are described in terms of stream length with utility corridors, private land uses or highway within stream buffer zones. Other road and utility corridor related issues are also discussed.

Road Length and Stream Crossings

Research shows that roads interact with surface and subsurface flow of water over hillslopes. This interaction may affect the hydrologic response of a watershed, including the timing and magnitude of the hydrograph. Wemple and Jones (2003) found that depending on the nature of storm events, watershed characteristics, and road segment attributes, storm flow response may be more rapid and have greater peaks because of the interaction roads have on hillslope flow.

Table B-1. Road Type and Location Summary Statistics

	First Degree Road Length* (miles)	Second Degree Road Length† (miles)	Third Degree Road Length§ (miles)	All roads (miles)
Total for Prospect Watershed				
	21.2	70.8	375.8	467.9
By Land Owner				
National Forest	15	59.6	348	422.5
Montana State	0	0	0	0
Private	6.2	11.2	27.8	45.2
By HUC 6 Watershed				
Clear	0.12	18.4	104	122.6
Cooper	0.18	0.41	17.9	18.4
Crow	0.10	16.6	39.4	56.1
Dry	1.06	10.7	32.2	43.9
Lower Prospect	11.9	11.5	139.9	163.3
Upper Prospect	7.8	4.4	28.9	41.2
Wilkes	0	8.8	13.5	22.3

* First Degree roads include main arterial and collector roads with 1-2 lanes, a high degree of user comfort, 35- 55 feet wide, and a non-native surface.
† Second Degree roads include local, collector or arterial single lane roads, are suitable for passenger cars or may require a high clearance vehicle, 15-25 feet wide, and may have native or non-native surface.
§ Third Degree roads include local and collector single lane roads, require a high clearance vehicle, may or may not be drivable, may be closed to public access (i.e. private roads), are 5-15 feet wide, have a native surface and limited to no traffic use.

Based on GIS data provided by the Lolo National Forest, approximately 468 miles of road and 307 stream crossings exist in the Prospect Creek watershed today (**Tables B-1 and B-2**). "Jammer" roads and skid trails are not included as roads on the GIS layer, and are therefore not

included in the summary statistics values provided below. Among the parameters evaluated was road density (length of road per area of land). Road density provides a metric for the degree of "roadedness" or development in a watershed and has been linked to a watersheds ability to support fish populations. The location of roads within stream buffers was also evaluated. Roads in close proximity to streams can deliver road sediment to the channel network and impact vegetation and recruitment of woody debris.

Table B-2. Stream Crossing Location Summary Statistics

HUC 6 Name	Total Stream Crossings	National Forest Land	Montana State Land	Private Land
Clear	76	60	0	16
Cooper	16	16	0	0
Crow	32	32	0	0
Dry	23	14	0	9
Lower Prospect	114	97	0	17
Upper Prospect	29	25	0	4
Wilkes	17	15	0	2
Total	**307**	**259**	**0**	**48**

Road Density

Road density for the Prospect Creek watershed and its tributary watersheds were evaluated **(Table B-3)**.

Table B-3. Road and Stream Length and Density Summary Statistics*

HUC 6 Name	HUC 6 Area (miles2)	Road Length (miles)	Road Density (mi/mi2)	Stream Length (miles)	Stream Density (mi/mi2)
Clear	28.6	122.6	4.3	51.6	1.8
Cooper	15.8	18.4	1.2	78.7	5.0
Crow	14.8	56.1	3.8	32.2	2.2
Dry	35.8	43.9	1.2	28.6	0.8
Lower Prospect	40.3	163.3	4.1	84.7	2.1
Upper Prospect	29.6	41.2	1.4	61.2	2.1
Wilkes	15.8	22.3	1.4	30.6	1.9
Total	**180.7**	**467.9**	**2.6**	**367.6**	**2.0**

*Statistics are based on GIS layers of the road and stream network and reported by HUC 6 watershed boundary.

The USDA Forest Service classified road density in examining the characteristics of aquatic/riparian ecosystems in the Columbia River Basin (CRB) (1996, **Table B-4**). Watersheds with greater than 4.7 mi/mi^2 have an "Extremely High" road density. "Very Low" road density is defined by 0.02 to 0.1 mi/mi^2.

The CRB study found that as road density in a watershed increases, the ability of the watershed to support strong populations of key salmonids is diminished. The effect is more pronounced when all land management types are considered, and less pronounced when only National Forest lands are considered. For all lands, about 8% of watersheds with "High" road density supported strong salmonids populations, whereas for National Forest lands, 22% of watersheds with "High" road density supported strong salmonids populations (**Figure B-3**).

Applying the CRB road density classification to GIS analysis of road density, the Prospect Creek watershed has "high" road density with 2.6 miles/mile^2 (**Table B-3**). Individual HUC 6 sub-watersheds also are in the "high" road density category, including Clear Creek (4.3 miles/mile^2), Crow Creek (3.8 miles/mile^2), and Lower Prospect Creek (4.1 miles/mile^2). Road density in the remaining HUC 6 sub-watersheds is "moderate".

Table B-4.Road density classification

Classification	Road Density (mi/mi2)
Extremely High	> 4.7
High	1.7 - 4.7
Moderate	0.7 - 1.7
Low	0.1 - 0.7
Very Low	0.02 - 0.1

Reference: USDA Forest Service, 1996

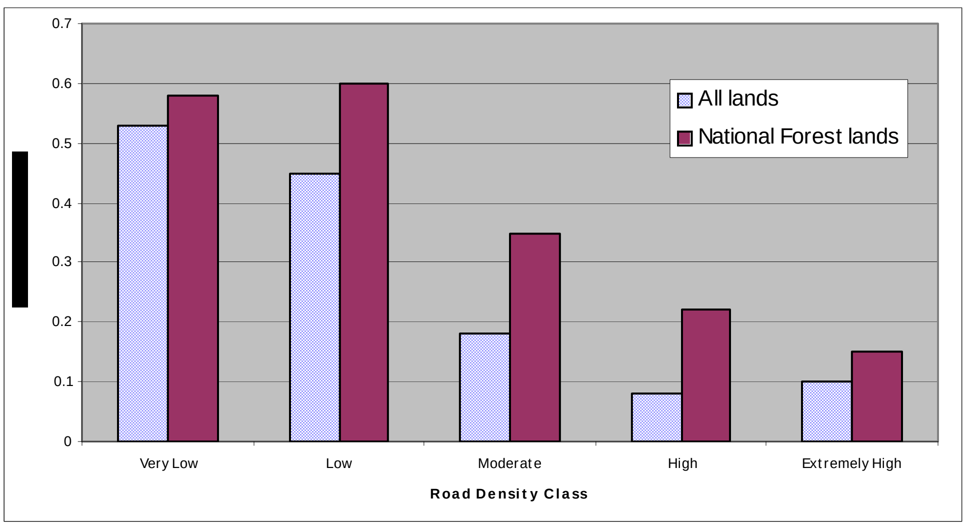


Figure B-1. Relationship between Road Density and Watershed Ability to Support Strong Populations of Key Salmonids
Adapted from USDA Forest Service, 1996

Stream density (length of stream/area of land) was also calculated. When comparing stream density to road density, Clear Creek, Crow Creek, Dry Creek, and Lower Prospect Creek HUC 6 watersheds have more length of road per square mile than length of stream (**Table B-3**).

Another way to examine stream or road density is to calculate and compare the average distance (Ad) between streams and between roads using the equation: **Ad = ½ (1/D)**, where D is density, the length of stream or road / area of land. In Clear Creek, for example, where Ds (stream density) is 1.8 mi/mi^2, Ad between streams (Ads) is 0.277 miles, and where Dr (road density) is 4.3 mi/mi^2, Ad between roads (Adr) is 0.116 miles:

Ads = ½ (1/1.8)	Adr = ½ (1/4.3)
= ½ (0.555)	= ½ (0.233)
= 0.277	= 0.116

This means that on average, a raindrop falling on the ground (assuming overland flow conditions) has more than twice as far to travel to get to a stream (1463 feet) as to a road (614 feet).

Road – Stream Proximity

Road density alone is not necessarily a good indicator of stream condition. The percent of stream length in close proximity to roads provides additional indicators of the potential impacts roads can have on streams. Those impacts may include alteration of riparian vegetation, sediment delivery, LWD recruitment, stream temperature, channel morphology, bank erosion, bank stability, sediment transport, and fish and aquatic habitat.

The 2000 Bull Trout baseline Section 7 Consultation study (Hendrickson, 2000) examined road-stream relationships using spatial analysis of GIS data including road and stream layers. One of the parameters evaluated by Hendrickson (2000) was the length of stream with roads within 125’ and 300’ (perpendicular distance). To characterize potential impacts of roads in the Prospect Creek watershed, a similar spatial analysis was conducted to evaluate the length of stream with utility lines within 125’ and 300’.

The 300’ buffer is based on a review of a large body of research on sediment delivery distances (Belt, et al. 1992). The review concluded that sediment within 300’ of a water body has the potential to be delivered to the water body despite the presence of vegetation buffers. Roads are a source of sediment, and when constructed in riparian areas their proximity to a water body increases the likelihood of that sediment being delivered to the water body. Additionally, roads within 300’ of a stream generally hinder the attainment of the INFISH Riparian Management Objective, RMO, which partially delineates the Riparian Habitat Conservation Area (RHCA) with a 300’ buffer from perennial, fish-bearing streams (INFISH,1995).

The 125’ buffer is used based on the average maximum height of the tree species most commonly found in riparian areas on the Lolo National Forest. Potential large woody debris recruitment is considered in terms of site potential tree height. In the region of the Lolo National Forest, mature trees within 125’ of a stream have the potential of falling into the stream, and thus being recruited as large woody debris. Roads within 125’ of streams preclude the growth of trees within the road template (often from top of cut slope to toe of the fill slope), decreasing the density of trees in the riparian area, and thus precluding the number of mature trees available for large woody debris recruitment. Clearing of riparian vegetation in these areas may also impact stream shading, stream temperature, bank erosion, and sediment delivery. The roads themselves may be a source of sediment, and when constructed in riparian areas their proximity to a water body increases the likelihood of that sediment being delivered to the water body. Based on research conducted by Belt and others, sediment within 300 feet of a water body has the potential to be delivered to the water body despite the presence of vegetation buffers (Belt, et al 1992). Additionally, roads within 300 feet of a stream generally hinder the attainment of the INFISH Riparian Management Objective (RMO) which partially delineates the Riparian Habitat Conservation Area (RHCA) with a 300 foot buffer from perennial, fish-bearing streams (INFISH, 1995).

In the Prospect Creek watershed, over 130 miles of road (29%) are located within 300 feet of streams and over 40 miles of road (9%) are located within 125' of stream (**Table B-5**).

Stream length encroached upon by roads includes 113 miles of stream within 300 feet of a road **(Table B-6)**. This represents 31 percent of total stream length in the watershed. Of this, approximately 40 miles or 11 percent of the total stream length is within 125 feet of a road.

Four out of seven of the HUC 6 tributary watersheds to the Prospect Creek watershed have greater than 30% of their streams' length encroached upon by roads within 300' (**Table B-6**). Dry Creek and Cooper Creek have the greatest percent stream length within 300' of road with 45 and 40 percents, respectively, while Clear, Crow and Cooper Creeks have the lowest with 23, 21, and 21 percents, respectively.

Percent of stream length within 125' of roads is greatest in Dry Creek with 21% and Lower Prospect with 19%, followed by Clear Creek with 15%. Cooper Creek, Upper Prospect and Wilkes Creek have less than 10% of their stream lengths within 125' of road. Eleven percent of Crow Creek stream length is within the site-potential tree height of road.

Table B-5. Road Lengths in Proximity to Streams

HUC 6 Name	Miles of road within 300' of streams	% HUC 6 road length within 300' of streams	Miles of road within 125' of streams	% HUC 6 road length within 125' streams
Clear	28.2	23	8.1	7
Cooper	7.4	40	2.3	12
Crow	11.6	21	4.0	7
Dry	19.7	45	6.5	15
Lower Prospect	49.9	31	17.3	11
Upper Prospect	12.3	30	4.0	10
Wilkes	4.7	21	1.3	6
Total	**133.8**	**29**	**43.6**	**9**

Table B-6. Stream Lengths in Proximity to Roads

HUC 6 Name	Miles of stream within 300' of roads	% HUC 6 stream length within 300' of roads	Miles of stream within 125' of roads	% HUC 6 stream length within 125' of roads
Clear	24.9	48	7.6	15
Cooper	6.2	8	2.2	3
Crow	10.0	31	3.5	11
Dry	17.7	62	5.9	21
Lower Prospect	40.7	48	15.7	19
Upper Prospect	10.1	17	3.6	6
Wilkes	3.5	11	1.2	4
Total	**113.1**	**31**	**39.7**	**11**

Utility Corridors and Private Land Uses

Utility corridors and other private land uses in close proximity to streams may have similar impacts on water quality as the road-related impact discussed above. Those impacts may include alteration of riparian vegetation, sediment delivery, LWD recruitment, stream temperature, channel morphology, bank erosion, bank stability, sediment transport, and fish and aquatic habitat. The same stream buffer distances used to analyze the length of stream with roads in close proximity were used to describe the length of stream with utility corridors and private land uses in close proximity.

Regular vegetation clearing in utility corridors that are within 125 feet of streams precludes establishment of mature trees in the riparian area, and thus restricts large woody debris recruitment to the stream. As discussed above for roads, clearing of riparian vegetation in these areas may also impact stream shading, stream temperature, bank erosion, and sediment delivery. Utility corridors and the roads used to access them may be a source of sediment, and when constructed in riparian areas their proximity (within 300 feet) to a water body increases the likelihood of that sediment being delivered to the water body despite the presence of vegetation buffers (Belt et al, 1992). Additionally, utility corridors including access roads within 300 feet of a stream generally hinder the attainment of the INFISH Riparian Management Objective (RMO) which partially delineates the Riparian Habitat Conservation Area (RHCA) with a 300 foot buffer from perennial, fish-bearing streams (INFISH, 1995).

Northwestern Energy, Bonneville Power Administration (BPA), and Yellowstone Pipeline (YPL) maintain utility corridors in the Prospect Creek watershed. The YPL route occurs in the valley bottom along the mainstem Prospect Creek upstream to Thompson Pass approximately 2.5 miles west of Twentyfour Mile Creek. The BPA route follows the valley bottom from Reach 1 upstream to the confluence with Crow Creek, at which point the transmission line enters the valley bottom of Crow Creek in close proximity to the channel. The Northwestern Energy utility corridor also traverses the Prospect Creek valley bottom upstream to Cooper Creek. At the confluence, it veers south and parallels the mainstem Cooper Gulch upstream to the watershed divide.

The length of stream with power lines and pipelines encroaching within 125 feet and 300 feet were evaluated using GIS buffer analysis. GIS layers of the power lines and pipelines (both original and re-routed sections) were used along with a GIS layer of the entire lengths of mainstems Prospect, Cooper and Crow creeks.

The length of stream with private land uses encroaching within 125 feet and 300 feet were also evaluated by aerial photo interpretation. Private land uses were categorized as residential development (residences and lawns), pasture, and timber management. Areas evaluated for private land uses included the lower 13.8 miles of Prospect Creek (up to Shamrock Gulch), the lower 2.1 miles of Dry Creek, and the lower 5.4 miles of Clear Creek.

Analysis results of stream length with utility corridors or private land uses within 125 feet and 300 feet buffers are presented in **Table B-7**.

Table B-7. Miles and Percent of Total Stream Length Within 125 ft and 300 ft of Utility Corridors and Private Land Uses

			Power Lines				YPL				Power Lines and YPL				Private Land Uses*			
Stream	**Total Length**	**Length Evaluated**	**125 ft**	**% of Total**	**300 ft**	**% of Total**	**125 ft**	**% of Total**	**300 ft**	**% of Total**	**125 ft**	**% of Total**	**300 ft**	**% of Total**	**125 ft**	**% of Total**	**300 ft**	**% of Total**
Prospect Creek~																		
	24.2	24.2	1.7	7%	4.4	18%	4.4	18%	10.1	42%	5.4	22%	11.3	47%	1.1	5%	3	12%
Clear Creek@																		
	12.1	5.4	--	--	--	--	--	--	--	--	--	--	--	--	1	8%	1.2	10%
Cooper Creek#																		
	6.6	6.6	1.3	20%	3.1	47%	0.1	2%	0.1	2%	1.4	21%	3.1	47%	--	--	--	--
Crow Creek^																		
	1.4	1.4	0.5	36%	0.7	50%	0.2	14%	0.3	21%	0.6	43%	0.7	50%	--	--	--	--
Dry Creek&																		
	4.2	2.1	--	--	--	--	--	--	--	--	--	--	--	--	0.3	7%	0.5	12%
*Residences, Lawns, Timber Management, or Pasture																		
Stream Length Evaluated:																		
~ Power and Pipe Lines: 24.2 miles from Clark Fork to headwaters; Private: 13.8 miles from Clark Fork to Shamrock Gulch																		
@ Private: lower 5.4 miles upstream from Prospect Creek																		
# Power and Pipe Lines: 6.6 miles from Prospect Creek to headwaters																		
^ Power and Pipe Lines: 1.4 miles from Prospect Creek to East-West Fork confluence																		
& Private: lower 2.1 miles upstream from Prospect Creek																		

As noted for the 125 foot and 300 foot buffers, approximately 5.4 miles (22%) and 11.3 miles (47%) of the total mainstem stream length (24.2 miles) are associated with utility corridors, respectively. Private land uses are associated with 1.1 miles (5%) and 3.0 miles (12%) of the 125 foot and 300 foot buffers of the length of Prospect Creek mainstem.

The length of Clear Creek evaluated for private land uses is 5.4 miles or 45 % of the length of Clear Creek (12.1 miles). Of the 5.4 miles evaluated, 1.0 mile (19%) and 1.2 miles (22%) of Clear Creek have private land uses within the 125 foot and 300 foot buffers, respectively. These private land uses represent 8% and 10% of the entire length of Clear Creek.

Of the total length of mainstem Cooper Creek (6.6 miles), power lines encroach upon 1.4 miles (21%) and 3.1 miles (47%) of stream within the 125 foot and 300 foot buffers respectively.

For Crow Creek mainstem (1.4 miles), power lines and pipeline encroach upon 0.6 miles (43%) and 0.7 miles (50%) of stream within the 125 foot and 300 foot buffers respectively.

The length of Dry Creek evaluated for private land uses is 2.1 miles or 50% of the length of Dry Creek (4.2 miles). Of the 2.1 miles evaluated, 0.3 miles (14%) and 0.5 miles (24%) of Dry Creek have private land uses within the 125 foot and 300 foot buffers, respectively. These private land uses represent 7% and 12% of the entire length of Dry Creek.

County Highway No. 471

A similar encroachment analysis to evaluate the impacts of County Highway No. 471 on the mainstem Prospect Creek was completed. As noted in **Table B-8** for the 125 foot and 300 foot buffers, approximately 1.9 miles (10.1%) and 6.7 miles (35.5%) of the total mainstem stream length are associated with the County Highway No. 471, respectively (**Table B-8**). The county highway in close proximity to streams has similar impacts on water quality as those discusses for roads and utility corridors in the sections above. Those impacts may include alteration of riparian vegetation, sediment delivery, LWD recruitment, stream temperature, channel morphology, bank erosion, bank stability, sediment transport, and fish and aquatic habitat.

Table B-8. Miles of Stream Length Within 125 ft and 300 ft of County Highway No. 471

125 ft	300 ft
1.9 miles	6.7 miles

Other Road- and Utility Corridor-Related Issues

In some areas, multiple land uses occur within the riparian buffer zones.

Additional road- and utility-related issues affecting water quality in Prospect Creek include are discussed in more detail in other sections of this document. **Appendix H** presents a more detailed stream crossing analysis in terms of culvert sizing and failure risk and in terms of fish passage capabilities. Stream crossing analysis results are also summarized in the Phase I assessment document (RDG, 2004). Bridge structures crossing Prospect Creek were reviewed in

2003. Results of the bridge review are presented in the Phase I assessment document (RDG 2004). Temperature loading results are presented in **Appendix I**.

References

Belt G. H., J. O' Laughlin and T. Merrill. 1992. Design of Forest Riparian Buffer Strips for the Protection of Water Quality: Analysis of Scientific Literature. Idaho Forest, Wildlife and Range Policy Analysis Group, Report No.8, Idaho Forest, Wildlife, and Range Experiment Station. Boise, ID: University of Idaho.

Hendrickson, S. and K. Cikanek. 2000. Middle Clark Fork River Section 7 Consultation Watershed Baseline Analysis. Missoula, MT: Lolo National Forest.

(INFISH), Inland Native Fish Strategy. 1995. Environmental Assessment: Decision Notice and Finding of No Significant Impact. Interim Strategies for Managing Fish-Producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana and Portions of Nevada. [Place of publication unknown]: U.S. Department of Agriculture, Forest Service, Intermountain, Northern, and Pacific Northwest Regions.

RDG (River Design Group, Inc.) and USFS Lolo National Forest. 2004. Final Prospect Creek Watershed Assessment and Water Quality Restoration Plan, pp. 65-66, 109. Whitefish, MT: River Design Group.

U.S. Forest Service. 1996. Integrated Scientific Assessment for Ecosystem Management In The Interior Columbia Basin And Portions Of The Klamath And Great Basins. GTR PNW-GTR-382. Washington, D.C.: United States Department of Agriculture.

Wemple, B.C. and J.A. Jones. 2003. Runoff Production on Forest Roads in a Steep, Mountain Catchment. *Water Resources Research* 39(8): 1220, doi:10.1029/2002WR001744.

APPENDIX C
RIPARIAN CANOPY ASSESSMENT

This appendix presents the information regarding two separate but associated riparian canopy assessments conducted along Prospect Creek during 2004 and 2005. Health and maturity of riparian corridors have a direct impact on stream morphology and habitat, sediment loading, and stream temperature. The information in this appendix also provides a reference to compare future riparian studies against. The results of the riparian canopy assessment provide the rationale for the riparian canopy targets presented in **Section 4.0**.

Introduction

Riparian areas perform many ecological functions that contribute to overall stream health. The vegetation within riparian areas helps to: stabilize streambanks, dissipate energy of floods, support perennial flows, trap sediment, and moderate stream temperature (Gregory et al., 1991; Elmore and Kauffman, 1994; Gurnell, 1997; Naiman and Decamps, 1997: Tabacchi et al., 1998; Tabacchi et al., 2000). Many of these functions are important for maintaining wildlife habitat, especially for endangered salmonids (see reviews by Kauffman and Krueger, 1984; Platts, 1991; Fitch and Adams, 1998; Naiman et al., 2000).

The history of resource extraction, the development of infrastructure, and the inhabitance of river valleys for residence and livelihood have impacted riparian corridors throughout Montana. The Prospect Creek watershed is no exception. Roads and utility corridors route through many stream bottoms and have altered not only the riparian composition but stream channel form and in-stream habitat as well. Agricultural and residential development in the watershed has also affected riparian health, all of which have decreased water quality and habitat conditions throughout the Prospect Creek watershed.

The following assessments were developed to investigate the current conditions of the riparian community along Prospect Creek, identify areas for potential improvement, and provide a baseline for subsequent study. An initial analysis of aerial photos was conducted to remotely identify general riparian community composition for Prospect Creek mainstem. A subsequent study was conducted in the field to verify the accuracy of the aerial photo interpretation, and correlate the aerial photo analysis results to observed conditions.

Aerial Photo Analysis

Methods

Canopy density analysis for the mainstem Prospect Creek was completed using the 1996 aerial photo series at a scale of 1 inch equals 300 feet. The analysis includes Reaches 2 through 5 and did not include Reach 1, a higher gradient B channel. Reach 1 is characterized by a confined channel in a steep canyon that terminates at the confluence with the Clark Fork River. Sampling locations for remote analysis were established in each stream reach, at equal intervals, enabling a minimum of 30 measurements. A map wheel determined exact sampling locations along the

mainstem where a planimeter-type grid, one inch square, with 41 holes was overlain on selected sites. This grid was orientated perpendicular to valley aspect, and encompassed the adjacent floodplain and bankfull channel with plot size determined by local meander belt width. When increased belt widths occurred, the grid size was enlarged to meet the additional area. The grid size was narrowed when the belt width decreased.

Within each selected site, the percent of forested (mature forest and thick willow/alder) land was derived by tallying the number of dots overlying forested areas and dividing by the total number of dots within the plot. Adjacent or influencing anthropogenic land uses were identified when present. Each site was mapped and numbered on the relevant aerial photo.

Data

Table C-1. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
2	1	2	150	pvt	NWE	highway		shrub/ small trees	pvt				shrub/ small trees	46
2	2	2	220	pvt	NWE	road	highway	mature trees	pvt	NWE	Restoration attempt		shrub/ small trees	47
2	3	1	100	pvt	highway			shrub/ small trees	pvt				shrub/ small trees	39
2	4	1	120	pvt	highway			bare ground/ grass/ shrub	pvt	road			bare ground/ grass	27
2	5	1	210	pvt	highway			bare ground/ grass/ shrub	pvt	BPA			shrub/ small trees	30
2	6	2	150	pvt	BPA	highway		mature trees	pvt	BPA			shrub/ small trees	68
2	7	1	130	USFS	highway			shrub/ small trees	fs	YPL (original)	NWE	road	shrub/ small trees	74
2	8	2	150	fs	highway			shrub/ small trees	fs				shrub/ small trees	74
2	9	1	90	fs	highway			bare ground/ grass	fs				mature trees	71
2	10	3	300	pvt	highway			shrub/ small trees	pvt	YPL (original)	NWE		shrub/ small trees	41
2	11	1	150	pvt	highway			shrub/ small trees	pvt	YPL (original)			shrub/ small trees	52
2	12	1	150	pvt	highway			bare ground/ grass	pvt	YPL (original)			shrub/ small trees	58

Table C-1. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
2	13	2	180	pvt	highway			bare ground/ grass	pvt	YPL (original)			shrub/ small trees	64
2	14	3	210	pvt	highway			shrub/ small trees	pvt	YPL (original)			grass/ shrub	44
2	15	1	165	pvt	highway			grass/ shrub/ small trees	pvt	YPL (original)			shrub/ small trees	39
2	16	1	100	pvt	highway			bare ground/ grass	pvt	YPL (original)	NWE		shrub/ small trees	68
2	17	3	300	pvt	NWE	highway		bare ground/ grass/ shrub	pvt	YPL (original)	NWE		shrub/ small trees	61
2	18	1	135	pvt	YPL (original)			mature trees	pvt				mature trees	77
2	19	1	150	pvt	road			mature trees	pvt	road			shrub/ small trees	74
2	20	1	150	pvt	road			shrub/ small trees	pvt	road			mature trees	68
2	21	2	150	pvt				shrub/ small trees	pvt	road			shrub/ small trees	81
2	22	2	170	pvt	residence			shrub/ small trees	pvt	residence	riparian development		bare ground/ grass	52
2	23	3	120	pvt				shrub/ small trees	pvt				mature trees	64
2	24	4	350	pvt	riparian	road	residence	bare	pvt				mature	55

Table C-1. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	**Site**	**# of Threads**	**Total Active Channel Width (feet)**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Percent Canopy**
					development			ground/ grass/ shrub					trees	
2	25	2	225	pvt				shrub	pvt				shrub/ small trees	63
2	26	2	350	pvt	residence	highway	NWE	shrub	pvt				shrub/ small trees	49
2	27	1	120	pvt	highway	NWE		shrub/ small trees	pvt				mature trees	49
2	28	1	210	pvt	highway	NWE		bare ground/ grass/ shrub	pvt				mature trees	37
2	29	3	200	pvt	highway	NWE		shrub	pvt				shrub/ small trees	51
2	30	2	375	pvt	residence	riparian development		shrub/ small trees	pvt				shrub/ small trees	60
2	31	1	225	pvt				small trees	pvt				shrub/ mature trees	68
3	1	1	120	pvt				shrub/ small trees	pvt				mature trees	77
3	2	2	300	pvt	residence	riparian development		grass/ shrub/ small trees	pvt				shrub/ small trees	49
3	3	1	150	fs/ pvt				shrub/ small trees	fs/ pvt				mature trees	72
3	4	1	120	fs	YPL (original)	highway	YPL (re-route)	bare ground/ grass/ shrub	fs	YPL (original)			shrub/ small trees	54

Table C-1. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
3	5	1	180	fs	YPL (original)			grass/ shrub/ small trees	fs	YPL (original)			shrub/ small trees	61
3	6	3	90	pvt				shrub/ small trees	pvt				shrub/ small trees	68
3	7	1	100	fs	pasture			grass/ shrub/ small trees	fs				mature trees	21
3	8	2	300	pvt	YPL (original)	NWE	riparian development	grass/ shrub/ small trees	pvt				shrub/ small trees	59
3	9	2	160	fs	YPL (original)	NWE		shrub/ small trees	fs				mature trees	54
3	10	1	225	pvt	highway	YPL (re-route)		bare ground/ grass	fs	NWE	YPL (original)		bare ground/ grass/ shrub/ mature trees	56
3	11	2	120	fs	YPL (original)	NWE		shrub/ small trees	fs				shrub/ small trees	76
3	12	2	190	pvt				shrub/ small trees	pvt				mature trees	72
3	13	2	375	pvt	residence	NWE	YPL (re-route)	bare ground/ grass/ shrub	pvt				shrub/ small trees	35
3	14	1	95	pvt				shrub/ small trees	pvt				mature trees	75

Table C-1. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	**Site**	**# of Threads**	**Total Active Channel Width (feet)**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Percent Canopy**
3	15	2	135	pvt				geadss/ shrub/ small trees	pvt				mature trees	66
3	16	3	110	pvt				shrub/ small trees	pvt				mature trees	71
3	17	2	120	fs	pasture			bare ground/ grass/ shrub	fs				mature trees	43
3	18	2	150	fs				mature trees	fs				shrub/ mature trees	74
3	19	1	225	fs	NWE	highway	YPL (re-route)	grass/ mature trees	fs	NWE	YPL (original)		grass/ shrub/ small trees	58
3	20	2	225	fs	highway	YPL (re-route)		bare ground/ grass/ shrub	fs	NWE			bare/ shrub/ small trees	64
3	21	1	100	fs	NWE	YPL (original)	road	bare ground/ grass	fs	road			mature trees	39
3	22	1	200	fs	YPL (original)			bare ground/ grass/ shrub	fs	NWE			shrub/ small trees	38
3	23	1	120	pvt	road	residence	riparian development	grass/ shrub/ small trees	pvt				small/ mature trees	31
3	24	1	95	fs	highway	YPL (re-route)		bare ground/	fs	NWE			shrub/ small trees	45

Table C-1. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
								grass						
3	25	1	210	fs	NWE	YPL (original)		shrub/ small trees	fs	NWE	YPL (original)		shrub/ small trees	58
3	26	2	190	fs	NWE	YPL (re-route)	highway/ BPA	shrub/ small trees	fs	NWE			grass/ shrub/ small trees	56
3	27	1	150	fs	YPL (original)			shrub/ small trees	fs				shrub/ small trees	65
3	28	1	120	fs				bare ground/ grass/ shrub	fs	YPL (original)	YPL (original)		grass/ shrub/ small trees	64
3	29	1	100	fs				bare ground/ grass/ shrub	fs	YPL (original)			grass/ shrub/ small trees	44
3	30	2	75	fs				shrub/ small trees	fs				shrub/ mature trees	71
3	31	3	65	fs				bare ground/ grass/ shrub	fs				shrub/ small trees	42
3	32	1	150	fs	fire			grass/ shrub/ small trees	fs	fire			shrub/ small trees	47
4	1	2	250	fs				bare ground/ grass	fs				mature trees	25

Table C-1. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	**Site**	**# of Threads**	**Total Active Channel Width (feet)**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Percent Canopy**
4	2	3	180	fs				bare ground/ grass/ shrub	fs				grass/ mature trees	32
4	3	3	250	fs				shrub/ small trees	fs	YPL (original)			grass/ shrub/ small trees	34
4	4	1	180	fs				shrub/ mature trees	fs	YPL (original)			shrub/ shrub/ small trees	46
4	5	2	195	fs				shrub/ small trees	fs	YPL (original)			grass/ shrub	26
4	6	3	225	fs				grass/ shrub/ small trees	fs	YPL (original)			grass/ shrub/ small trees	18
4	7	3	300	fs					fs	YPL (original)	road	riparian development	bare/ grass/ shrub	17
4	8	2	300	fs				bare ground/ grass/ shrub	fs	road	YPL (original)	NEW	bare/ grass/ shrub	14
4	9	2	300	fs				mature trees	fs	road	NWE	YPL (original)	grass/ shrub/ small trees	25
4	10	2	270	fs				shrub/ mature trees	fs	road	NWE	YPL (original)	grass/ shrub	31
4	11	2	200	fs				mature trees	fs	road	NWE	YPL (original and re-route)	grass/ shrub	25

Table C-1. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
4	12	1	225	fs	riparian development			grass/ shrub/ small trees	fs	riparian development	NWE	YPL (original and re-route)	bare/ grass/ shrub	28
4	13	1	120	fs				shrub/ small trees	fs				shrub/ small trees	46
4	14	2	70	fs	road			bare ground/ grass/ shrub	fs	road			shrub/ mature trees	44
4	15	1	90	fs				grass/ shrub/ small trees	fs				grass/ shrub/ small trees	39
4	16	1	105	fs				mature trees	fs				shrub/ small trees	41
4	17	1	120	fs				mature trees	fs				mature trees	54
4	18	2	135	fs				mature trees	fs				mature trees	39
4	19	2	115	fs				mature trees	fs				mature trees	52
4	20	1	115	fs				mature trees	fs				mature trees	61
4	21	1	135	fs				mature trees	fs	YPL (original)	road	highway	shrub/ small trees	34
4	22	1	90	fs				mature trees	fs	YPL (original)	road		grass/ mature trees	61
4	23	2	75	fs				mature trees	fs				mature trees	90

Table C-1. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	**Site**	**# of Threads**	**Total Active Channel Width (feet)**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Percent Canopy**
4	24	1	65	fs				mature trees	fs				mature trees	90
4	25	1	75	fs				mature trees	fs				mature trees	71
4	26	2	90	fs				mature trees	fs				grass/ mature trees	63
4	27	2	110	pvt	riparian clearing	road		bare ground/ grass/ shrub	pvt	riparian development			grass/ shrub/ small trees	32
4	28	2	105	fs				mature trees	fs				mature trees	76
4	29	2	150	fs				shrub/ small trees	fs	YPL (original)			mature trees	49
4	30	2	190	fs				shrub/ small trees	fs	YPL (original)			shrub/ small trees	40
5	1	1	40	pvt	YPL (original)			mature trees	pvt	riparian development	road	YPL (original)	mature trees	59
5	2	2	80	fs/ pvt	riparian clearing	road		grass/ shrub	fs/ pvt	YPL (original)			shrub/ mature trees	53
5	3	1	60	fs				mature trees	fs	YPL (original)	YPL (re-route)		mature trees	56
5	4	1	50	fs				mature trees	fs				shrub/ mature trees	53

Table C-1. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
5	5	1	75	fs				mature trees	fs				shrub/ small trees	50
5	6	2	50	fs				mature trees	fs				mature trees	57
5	7	1	40	fs				bare ground/ grass/ mature trees	fs				mature trees	43
5	8	2	40	fs				mature trees	fs				shrub/ small trees	50
5	9	1	45	fs				mature trees	fs				mature trees	61
5	10	2	90	fs				mature trees	fs	YPL (original)	highway	YPL (re-route)	grass/ shrubs/ mature trees	56
5	11	1	75	fs				shrub/ small trees	fs	YPL (original)	highway	YPL (re-route)	grass/ shrub/ small trees	16
5	12	1	75	fs				shrub/ small trees	fs	YPL (original)			shrub/ small trees	31
5	13	2	100	fs	YPL (original)			shrub/ small trees	fs	YPL (original)	highway		shrub/ small trees	53
5	14	1	90	fs				mature trees	fs	YPL (original)	highway	YPL (re-route)	grass/ shrub/ small trees	53

Table C-1. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
5	15	1	90	fs	YPL (original)	highway	YPL (re-route)	bare ground/ grass/ shrub	fs	YPL (original)	YPL (re-route)	highway	shrub/ small trees	30
5	16	1	30	fs	YPL (original)			grass/ small trees	fs				mature trees	57
5	17	1	30	fs				mature trees	fs				mature trees	87
5	18	1	20	fs				mature trees	fs				mature trees	87
5	19	1	25	fs				shrub/ mature trees	fs				mature trees	74
5	20	1	45	fs	YPL (original)	highway	YPL (re-route)	grass/ mature trees	fs				mature trees	78
5	21	1	20	fs	YPL (original)	highway	YPL (re-route)	bare ground/ grass	fs				mature trees	50
5	22	1	20	fs	YPL (original)	highway	YPL (re-route)	grass/ shrub/ small trees	fs				mature trees	50
5	23	1	20	fs	YPL (original)	highway	YPL (re-route)	grass/ shrub/ small trees	fs				mature trees	64
5	24	1	55	fs	highway	YPL (re-route)		bare ground/ grass	fs	YPL (original)			shrub/ small trees	43

Table C-1. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	**Site**	**# of Threads**	**Total Active Channel Width (feet)**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Percent Canopy**
5	25	1	30	fs	highway	YPL (re-route)		bare ground/ grass/ shrub	fs	YPL (original)			shrub/ mature trees	50
5	26	1	30	fs	highway	YPL (re-route)		bare ground/ grass/ shrub	fs	YPL (original)			shrub/ small trees	50
5	27	2	45	fs	YPL (original)			shrub/ small trees	fs	YPL (original)			mature trees	43
5	28	1	25	fs	YPL (original)	highway	YPL (re-route)	grass/ shrub/ small trees	fs				mature trees	57
5	29	1	20	fs	highway	YPL (original)		grass/ mature trees	fs				mature trees	71
5	30	1	25	fs				shrub/ small trees	fs				mature trees	64
5	31	1	20	fs				mature trees	fs				mature trees	71

Field Analysis Using Densiometer

Methods

On August 30, 2005, Montana DEQ collected field measurements of riparian canopy density at some of the aerial photo sample sites using the EMAP method (Lazorchak, 2000). Sites were chosen for consistent vegetation composition between right bank and left bank, representative widths for the reaches, and site accessibility. Sites were chosen in the office from aerial photo analysis information and aerial photo review and adapted in the field based on encountered conditions. A densitometer was used to measure canopy shading on the stream at three cross-sections within the aerial photo sample site. Cross sections were located in the middle of aerial photo sample site, at an upstream location within the site, and at a downstream location within the site. For each cross-section, a densitometer reading was taken at the left bank, the right bank, and in the middle of the channel. All readings were taken with the densitometer at 1 foot above the water surface. All values were averaged to determine canopy density for the aerial photo site. (Lindgren, H., pers. comm., 2005)

Data

Table C-2. 2005 Densiometer Field Study

Reach	Field Canopy Cover	Field LB Vegetation	Field RB Vegetation	Active Channel Width
2-4	8%	shrub/small trees/grass on gravel bars	shrub/small trees/grass on gravel bars	120
2-8	12%	shrub/small trees	shrub/small trees	150
2-11	19%	road/grass/shrub	shrub/small trees	150
2-29	28%	bare/grass	mature trees	200
3-10	13%	rx/grass/shrub/ small trees	rx/grass	225
3-11	41%	grass/shrub/ small trees	trees	120
3-25	8%	grass/shrub/ small trees	grass/shrub/ small trees	210
3-26	34%	grass/shrub/ small trees	mature trees	190
4-21	34%	mature trees	shrub/small trees	135
5-11	54%	grass/shrub/ small trees	mature trees	75
5-13	44%	shrub/ small trees	shrub/ small trees	100
5-17	76%	mature trees	mature trees	30
5-29	81%	mature trees	mature trees	20

Discussion

In these analyses, canopy density is looked to as a surrogate for bank stability, and its link to properly functioning stream morphology and sediment loading. Additionally, although not specified as a pollutant on the 2006 list, temperature is also directly tied to canopy density as it effectively reduces the thermal loading to the stream. This relationship is especially important to the bull trout and westslope cutthroat trout in the watershed.

When reviewing the aerial photo analysis, it appears that on average, there is little distinguishable difference in canopy density from one reach to another (**Table C-3**). Mean canopy densities range from 43.4% - 56.4%. These canopy densities do not represent potential or historic conditions however as the Prospect Creek watershed has a legacy of alteration to the riparian corridors, especially lower in the watershed where valley width increases.

Table C-3. Aerial Photo Canopy Density Analysis Summary Table

Variable	Reach 2	Reach 3	Reach 4	Reach 5
Mean (%)	56.4	51	43.4	55.5
Minimum (%)	26.8	22	13.6	15.6
Maximum (%)	81.4	76.3	90.2	87.0
Sample Size	31	32	30	31

However limited in the number of sites that were field assessed, there is some information that can be gathered from the field verification study. As expected, in the field study canopy densities are higher in those areas dominated by mature riparian forest, which correlate to the upper, less disturbed areas of the watershed (Reach 5). This reach also has a more consistent relationship between the observed canopy density and the aerial photo interpretations for the field verified sites; 64% field derived mean canopy density for Reach 5, versus 57% interpreted mean canopy density.

Although the number of field verified sites is a small fraction of the total sites studied in the photo analysis, the similar results from both the field and remote exercise in Reach 5 allow for confidence in the results of the other photo interpreted Reach 5 sites. Reach 5 is further up the watershed and is characterized by riparian areas that are dominated by mature trees and smaller active channel widths (average width 46 feet). The mature tree riparian environment is the desired condition for the entire Prospect Creek watershed riparian corridor.

Lower in the watershed (Reaches 2-3) the relationship becomes significantly less between the results of the aerial photo interpretation and the actual observed field canopy density. Photo interpreted results show a mean canopy density of 59%, while field observed measurements show only 25% mean canopy density for the compared sites. Some of this discrepancy may be because the lower reaches are predominated by shrub/small tree and grass, the amount of canopy cover they provide may have been overestimated in the aerial photo analysis. However, because the relationship between the projected canopy percentages for mature trees in Reach 5 is consistent between the two methods, the assumption is made that those sites in the lower watershed that were identified as having mature trees on both banks is also similar to what we would expect if field verified. Nine sites were identified as having mature trees as the dominant

vegetation on both banks in the lower watershed. Mean canopy density as determined from aerial photo analysis at these sites is 62%.

The upper watershed (Reach 5) is predominantly characterized by mature tree composition and active channel widths less than 75 feet. Lower watershed reaches (2-4) are predominated by shrub/small trees and have an average active channel width of 169 feet and occur as wide as 375 feet. Since the mature tree dominated riparian area is the most desired condition, riparian canopy cover targets of 75% or better for upper reaches (reaches <75’), and riparian canopy cover of 60% or better for reaches >75’.

Table C-4. Comparison of DEQ Field Data and Aerial Photo Canopy Density Analysis on Mainstem of Prospect Creek

Reach-Site	Field Canopy Cover (%)	Aerial Photo Canopy Cover (%)	Field # of Threads	Aerial Photo # of Threads	Field LB Vegetation	Field RB Vegetation	Aerial Photo LB Vegetation	Aerial Photo RB Vegetation	Total Active Channel Width*
2-4	8	27	1	1	shrub/ small trees/grass on gravel bars	shrub/ small trees/grass on gravel bars	bare ground/ grass	bare ground/ grass	120
2-8	12	74	Middle xsection:2 Up and Down xsections:1	2	shrub/small trees	shrub/small trees	shrub/ small trees	shrub/ small trees	150
2-11	19†	52	Upper and Middle xsections:2 Down stream xsection:1	1	road/shrub/ grass	shrub/ small trees	shrub/ small trees	shrub/ small trees	150
2-29	28	51	1	3	Bare ground/grass	mature trees	shrub/ small trees	shrub/ small trees	200
3-10	13	56	1	1	rx/grass/ small trees	rx/grass	bare ground/ grass	bare ground/ grass	225
3-11	41	76	1	2	grass/shrub/ small trees	mature trees	shrub/ small trees	shrub/ small trees	120
3-25	8∞	58	1 active	1	grass/shrub/ small trees	grass/shrub/ small trees	shrub/ small trees	shrub/ small trees	210
3-26	34	56	1	2	grass/shrub/ small trees	mature trees	shrub/ small trees	shrub/ small trees	190
4-21	34	34	DRY - readings are for potential canopy cover	1	mature trees	shrub/small trees	mature trees	shrub/ small trees	135
5-11	54	16	1	1	grass/shrub	mature trees	shrub/ small trees	shrub/ small trees	75
5-13	44	53	1 (side channel was dry)	2	shrub/small trees	shrub/small trees	shrub /small trees	shrub/ small trees	100

Table C-4. Comparison of DEQ Field Data and Aerial Photo Canopy Density Analysis on Mainstem of Prospect Creek

Reach-Site	Field Canopy Cover (%)	Aerial Photo Canopy Cover (%)	Field # of Threads	Aerial Photo # of Threads	Field LB Vegetation	Field RB Vegetation	Aerial Photo LB Vegetation	Aerial Photo RB Vegetation	Total Active Channel Width*
5-17	76	87	1	1	mature trees	mature trees	mature trees	mature trees	30
5-29	81	71	1	1	mature trees	mature trees	mature trees	mature trees	20

* Values from Aerial Photo Analysis
† 2-11: Large variability from 1996 photo
∞ 3-25: Power line disturbance

The history of logging and the development of infrastructure (roads, powerlines, etc) in the area have altered riparian corridors throughout the watershed. Literature shows restoring the riparian corridor, where appropriate, will improve stream morphology and habitat and is the only identified effective means for reducing temperature in the Prospect Creek watershed. If the riparian canopy targets are met, over time, lower width/depth ratios will likely also result producing smaller but deeper channels which improve habitat conditions for sensitive fish species. Additionally, the amount of surface area of the stream will be reduced also helping to reduce temperature, and allow the stream to recruit more woody debris which in turn produces more complex habitat through the development of varied morphology, more and deeper pools, and increased diversity in macroinvertebrate habitat.

It is acknowledged that this study and the resulting recommendations are based on very limited data and statistical analysis. Further verification of riparian conditions in the field is strongly recommended, as well as assessment of riparian potential. Due to the presence of utility corridors and infrastructure in the watershed it is also recognized that these riparian goals may not always be achievable. It is understood that it will take many years or decades to completely accomplish these recommendations, however the analysis of the riparian corridors and investigation into alternative management options where the riparian areas coincide with infrastructure, should be one of the first steps to achieving the TMDL for Prospect Creek watershed.

References

Elmore, W., and J. B. Kauffman. 1994. Riparian and Watershed Systems: Degradation and Restoration. In: Ecological Implications of Livestock Herbivory. Denver, CO: Western Society of Range Management.

Fitch, L. and R. L. Adams. 1998. Can Cows and Fish Co-Exist? *Canadian Journal of Plant Science* 78(2):191-8.

Gregory, S. V., F. J. Swanson, W. A. McKee, and K. W. Cummins. 1991. An Ecosystem Perspective of Riparian Zones: Focus on Links Between Land and Water. *BioScience* 41(8):540-551.

Gurnell, A. 1997. The Hydrological and Geomorphological Significance of Forested Floodplains. *Global Ecology and Biogeography Letters*. 6:219-229.

Kauffman, J. B. and W. C. Krueger. 1984. Livestock Impacts on Riparian Ecosystems and Streamside Management Implications…A Review. *Journal of Range Management.* 37(5):430-438.

Naiman, R. J., R. E. Bilby, and P. A. Bisson. 2000. Riparian Ecology and Management in the Pacific Coastal Rain Forest. *BioScience*. 50:11.

Naiman, R. J., and H. Decamps. 1997. The Ecology of Interfaces: Riparian Zones. *Annual Review of Ecology and Systematics.* 28:621-658.

Platts, W. S. 1991. Livestock Grazing. In: Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats. *American Fisheries Society Special Publication.* 19:389-423.

Tabacchi, E. D. L. Correll, R. Hauer, G. Pinay, A. Planty-Tabacchi, and R. C. Wissmar. 1998. Development, Maintenance and Role of Riparian Vegetation in the River Landscape. *Freshwater Biolog.y* 40:497-516.

Tabacchi, E., L. Lambs, H. Guilloy, A. Planty-Tabacchi, E. Muller and H. Decamps. 2000. Impacts of Riparian Vegetation on Hydrological Processes. *Hydrological Processes.* 14:2959-2976.

APPENDIX D
DAILY SEDIMENT TMDLS

Introduction

Sediment TMDLs are often based on analysis of annual loads. The means by which to determine annual loads from a given sediment source inherently incorporate some margin of safety, assumption, and error that when balanced over the course of 365 days still provide a reasonable account for the appropriate Total Maximum Daily Load for a given year. Annual load analysis also allows for a relative percent reduction strategy by which to convey the TMDL. At the time this document was developed, TMDL as percent reduction from annual loads was an acceptable development strategy approved by the EPA and allows for interpretation of narrative standards without necessarily defining absolute numeric values. This is especially appropriate when considering that: multiple source loads are quantified using a variety of methods; all significant sediment sources are driven by nonpoint source runoff; and impacts to beneficial uses are predominantly from accumulative, chronic sediment loading, rather than daily acute exceedences of the narrative water quality standard for sediment. The TMDLs and allocations for the Prospect Creek Watershed are presented in this manner in **Section 6.0** of this document.

Recent recommendation from EPA requests the inclusion of Total Maximum Daily Loads as a direct translation of the term Total Maximum *Daily* Load within each produced TMDL document. **Appendix D** is included to satisfy that recommendation.

The daily loads provided in this appendix are estimates based on the mean annual hydrograph at USGS gage station (12390700) for Prospect Creek at Thompson Falls, MT (**Figure D-1**), and the derived annual sediment source loads as presented in **Section 5.0.** The annual hydrograph at this station approximates the timing and relative daily magnitude of flows in impaired watersheds in Prospect Creek, Clear Creek, and Dry Creek. For each day, the percentage of the total annual flow was calculated and multiplied by the annual allowable load to obtain an average approximation of the allowable load for any single day. Actual loads on any given day may be in excess of the allowable load given due to a variety of natural and non-natural factors (timing of the annual hydrograph, weather patterns, storm events, or other natural and non-natural watershed disturbances), however, daily exceedances may not contribute to impairment conditions unless frequency and duration of non-natural loads, over time, is excessive. **Table D-1** presents the mean discharge and TMDL for each calendar day, for each watershed of interest.

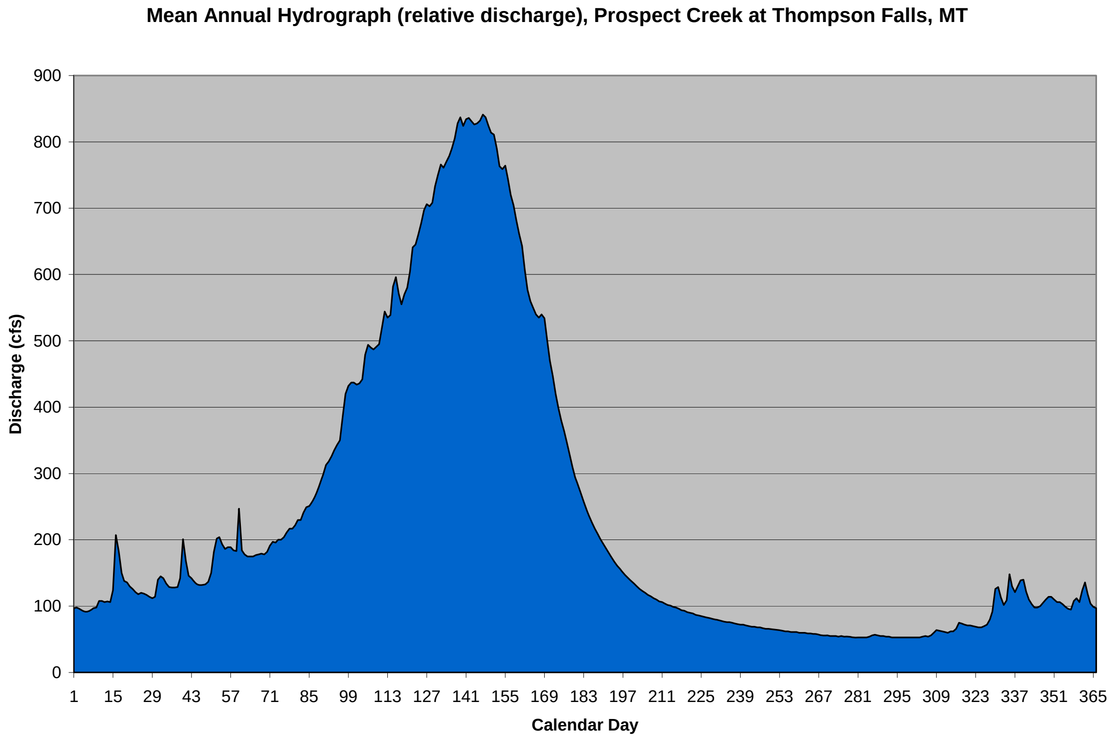


Figure D-1. Mean Annual Hydrograph (Relative Discharge), Prospect Creek at Thompson Falls, MT: USGS Station12390700

Table D-1. Sediment Total Maximum Daily Loads for Prospect Creek, Clear Creek, and Dry Creek

Calendar Day	Mean Discharge	Percent of Annual Flow	TMDL Prospect	TMDL Clear	TMDL Dry
1	97	0.113%	33.77861	5.453165	4.703737
2	98	0.114%	34.12684	5.509383	4.752229
3	96	0.112%	33.43037	5.396947	4.655245
4	93	0.109%	32.38567	5.228292	4.509768
5	92	0.107%	32.03744	5.172074	4.461276
6	92	0.107%	32.03744	5.172074	4.461276
7	94	0.110%	32.73391	5.284511	4.558261
8	97	0.113%	33.77861	5.453165	4.703737
9	98	0.114%	34.12684	5.509383	4.752229
10	108	0.126%	37.60917	6.071565	5.23715
11	108	0.126%	37.60917	6.071565	5.23715
12	106	0.124%	36.9127	5.959129	5.140166
13	107	0.125%	37.26094	6.015347	5.188658
14	106	0.124%	36.9127	5.959129	5.140166
15	124	0.145%	43.1809	6.971056	6.013025
16	207	0.242%	72.08424	11.63717	10.03787

Table D-1. Sediment Total Maximum Daily Loads for Prospect Creek, Clear Creek, and Dry Creek

Calendar Day	Mean Discharge	Percent of Annual Flow	TMDL Prospect	TMDL Clear	TMDL Dry
17	183	0.214%	63.72665	10.28793	8.874061
18	150	0.175%	52.23496	8.43273	7.27382
19	138	0.161%	48.05616	7.758111	6.691914
20	136	0.159%	47.35969	7.645675	6.59493
21	130	0.152%	45.2703	7.308366	6.303977
22	126	0.147%	43.87736	7.083493	6.110009
23	121	0.141%	42.1362	6.802402	5.867548
24	118	0.138%	41.0915	6.633747	5.722072
25	120	0.140%	41.78797	6.746184	5.819056
26	119	0.139%	41.43973	6.689965	5.770564
27	117	0.137%	40.74327	6.577529	5.67358
28	114	0.133%	39.69857	6.408874	5.528103
29	112	0.131%	39.0021	6.296438	5.431119
30	114	0.133%	39.69857	6.408874	5.528103
31	140	0.163%	48.75263	7.870548	6.788899
32	145	0.169%	50.49379	8.151639	7.031359
33	142	0.166%	49.44909	7.982984	6.885883
34	134	0.156%	46.66323	7.533238	6.497946
35	129	0.151%	44.92206	7.252147	6.255485
36	128	0.149%	44.57383	7.195929	6.206993
37	128	0.149%	44.57383	7.195929	6.206993
38	129	0.151%	44.92206	7.252147	6.255485
39	142	0.166%	49.44909	7.982984	6.885883
40	201	0.235%	69.99484	11.29986	9.746919
41	168	0.196%	58.50315	9.444657	8.146678
42	146	0.170%	50.84202	8.207857	7.079852
43	142	0.166%	49.44909	7.982984	6.885883
44	137	0.160%	47.70793	7.701893	6.643422
45	133	0.155%	46.31499	7.47702	6.449454
46	132	0.154%	45.96676	7.420802	6.400962
47	132	0.154%	45.96676	7.420802	6.400962
48	133	0.155%	46.31499	7.47702	6.449454
49	137	0.160%	47.70793	7.701893	6.643422
50	150	0.175%	52.23496	8.43273	7.27382
51	182	0.212%	63.37841	10.23171	8.825568
52	202	0.236%	70.34307	11.35608	9.795411
53	204	0.238%	71.03954	11.46851	9.892395
54	193	0.225%	67.20898	10.85011	9.358982
55	186	0.217%	64.77135	10.45658	9.019537
56	189	0.221%	65.81605	10.62524	9.165013

Table D-1. Sediment Total Maximum Daily Loads for Prospect Creek, Clear Creek, and Dry Creek

Calendar Day	Mean Discharge	Percent of Annual Flow	TMDL Prospect	TMDL Clear	TMDL Dry
57	189	0.221%	65.81605	10.62524	9.165013
58	184	0.215%	64.07488	10.34415	8.922553
59	183	0.214%	63.72665	10.28793	8.874061
60	247	0.288%	86.01356	13.88589	11.97756
61	184	0.215%	64.07488	10.34415	8.922553
62	178	0.208%	61.98548	10.00684	8.6316
63	175	0.204%	60.94078	9.838184	8.486123
64	175	0.204%	60.94078	9.838184	8.486123
65	175	0.204%	60.94078	9.838184	8.486123
66	177	0.207%	61.63725	9.950621	8.583108
67	178	0.208%	61.98548	10.00684	8.6316
68	179	0.209%	62.33371	10.06306	8.680092
69	178	0.208%	61.98548	10.00684	8.6316
70	182	0.212%	63.37841	10.23171	8.825568
71	191	0.223%	66.51251	10.73768	9.261998
72	197	0.230%	68.60191	11.07498	9.55295
73	196	0.229%	68.25368	11.01877	9.504458
74	200	0.233%	69.64661	11.24364	9.698427
75	200	0.233%	69.64661	11.24364	9.698427
76	204	0.238%	71.03954	11.46851	9.892395
77	211	0.246%	73.47717	11.86204	10.23184
78	217	0.253%	75.56657	12.19935	10.52279
79	217	0.253%	75.56657	12.19935	10.52279
80	222	0.259%	77.30774	12.48044	10.76525
81	230	0.268%	80.0936	12.93019	11.15319
82	230	0.268%	80.0936	12.93019	11.15319
83	241	0.281%	83.92416	13.54859	11.6866
84	249	0.291%	86.71003	13.99833	12.07454
85	251	0.293%	87.40649	14.11077	12.17153
86	256	0.299%	89.14766	14.39186	12.41399
87	265	0.309%	92.28176	14.89782	12.85042
88	275	0.321%	95.76409	15.46	13.33534
89	285	0.333%	99.24642	16.02219	13.82026
90	298	0.348%	103.7734	16.75302	14.45066
91	313	0.365%	108.9969	17.5963	15.17804
92	318	0.371%	110.7381	17.87739	15.4205
93	326	0.380%	113.524	18.32713	15.80844
94	335	0.391%	116.6581	18.8331	16.24486
95	343	0.400%	119.4439	19.28284	16.6328
96	350	0.408%	121.8816	19.67637	16.97225

Table D-1. Sediment Total Maximum Daily Loads for Prospect Creek, Clear Creek, and Dry Creek

Calendar Day	Mean Discharge	Percent of Annual Flow	TMDL Prospect	TMDL Clear	TMDL Dry
97	387	0.452%	134.7662	21.75644	18.76646
98	420	0.490%	146.2579	23.61164	20.3667
99	432	0.504%	150.4367	24.28626	20.9486
100	437	0.510%	152.1778	24.56735	21.19106
101	437	0.510%	152.1778	24.56735	21.19106
102	434	0.507%	151.1331	24.3987	21.04559
103	436	0.509%	151.8296	24.51113	21.14257
104	442	0.516%	153.919	24.84844	21.43352
105	479	0.559%	166.8036	26.92852	23.22773
106	494	0.577%	172.0271	27.77179	23.95511
107	490	0.572%	170.6342	27.54692	23.76115
108	487	0.568%	169.5895	27.37826	23.61567
109	491	0.573%	170.9824	27.60313	23.80964
110	495	0.578%	172.3754	27.82801	24.00361
111	520	0.607%	181.0812	29.23346	25.21591
112	544	0.635%	189.4388	30.5827	26.37972
113	535	0.624%	186.3047	30.07674	25.94329
114	539	0.629%	187.6976	30.30161	26.13726
115	582	0.679%	202.6716	32.71899	28.22242
116	596	0.696%	207.5469	33.50605	28.90131
117	571	0.666%	198.8411	32.10059	27.68901
118	555	0.648%	193.2693	31.2011	26.91313
119	570	0.665%	198.4928	32.04437	27.64052
120	580	0.677%	201.9752	32.60655	28.12544
121	604	0.705%	210.3328	33.95579	29.28925
122	641	0.748%	223.2174	36.03586	31.08346
123	645	0.753%	224.6103	36.26074	31.27743
124	660	0.770%	229.8338	37.10401	32.00481
125	677	0.790%	235.7538	38.05972	32.82917
126	697	0.813%	242.7184	39.18408	33.79902
127	706	0.824%	245.8525	39.69005	34.23545
128	703	0.820%	244.8078	39.52139	34.08997
129	708	0.826%	246.549	39.80248	34.33243
130	733	0.855%	255.2548	41.20794	35.54473
131	750	0.875%	261.1748	42.16365	36.3691
132	766	0.894%	266.7465	43.06314	37.14497
133	761	0.888%	265.0053	42.78205	36.90251
134	770	0.899%	268.1394	43.28801	37.33894
135	779	0.909%	271.2735	43.79398	37.77537
136	790	0.922%	275.1041	44.41238	38.30879

Table D-1. Sediment Total Maximum Daily Loads for Prospect Creek, Clear Creek, and Dry Creek

Calendar Day	Mean Discharge	Percent of Annual Flow	TMDL Prospect	TMDL Clear	TMDL Dry
137	805	0.939%	280.3276	45.25565	39.03617
138	828	0.966%	288.337	46.54867	40.15149
139	837	0.977%	291.4711	47.05463	40.58792
140	824	0.962%	286.944	46.32379	39.95752
141	834	0.973%	290.4264	46.88598	40.44244
142	836	0.976%	291.1228	46.99841	40.53942
143	831	0.970%	289.3817	46.71732	40.29696
144	826	0.964%	287.6405	46.43623	40.0545
145	828	0.966%	288.337	46.54867	40.15149
146	832	0.971%	289.7299	46.77354	40.34546
147	841	0.982%	292.864	47.2795	40.78188
148	837	0.977%	291.4711	47.05463	40.58792
149	824	0.962%	286.944	46.32379	39.95752
150	814	0.950%	283.4617	45.76161	39.4726
151	811	0.947%	282.417	45.59296	39.32712
152	790	0.922%	275.1041	44.41238	38.30879
153	763	0.890%	265.7018	42.89448	36.9995
154	759	0.886%	264.3089	42.66961	36.80553
155	764	0.892%	266.05	42.9507	37.04799
156	745	0.869%	259.4336	41.88256	36.12664
157	720	0.840%	250.7278	40.4771	34.91434
158	704	0.822%	245.1561	39.57761	34.13846
159	682	0.796%	237.4949	38.34081	33.07164
160	661	0.771%	230.182	37.16023	32.0533
161	643	0.750%	223.9138	36.1483	31.18044
162	607	0.708%	211.3775	34.12445	29.43473
163	577	0.673%	200.9305	32.4379	27.97996
164	560	0.654%	195.0105	31.48219	27.15559
165	550	0.642%	191.5282	30.92001	26.67067
166	540	0.630%	188.0458	30.35783	26.18575
167	535	0.624%	186.3047	30.07674	25.94329
168	540	0.630%	188.0458	30.35783	26.18575
169	534	0.623%	185.9564	30.02052	25.8948
170	501	0.585%	174.4648	28.16532	24.29456
171	470	0.549%	163.6695	26.42255	22.7913
172	447	0.522%	155.6602	25.12953	21.67598
173	420	0.490%	146.2579	23.61164	20.3667
174	399	0.466%	138.945	22.43106	19.34836
175	380	0.443%	132.3286	21.36291	18.42701
176	364	0.425%	126.7568	20.46342	17.65114

Table D-1. Sediment Total Maximum Daily Loads for Prospect Creek, Clear Creek, and Dry Creek

Calendar Day	Mean Discharge	Percent of Annual Flow	TMDL Prospect	TMDL Clear	TMDL Dry
177	348	0.406%	121.1851	19.56393	16.87526
178	329	0.384%	114.5687	18.49579	15.95391
179	310	0.362%	107.9522	17.42764	15.03256
180	294	0.343%	102.3805	16.52815	14.25669
181	282	0.329%	98.20172	15.85353	13.67478
182	270	0.315%	94.02292	15.17891	13.09288
183	258	0.301%	89.84412	14.50429	12.51097
184	246	0.287%	85.66533	13.82968	11.92906
185	236	0.275%	82.183	13.26749	11.44414
186	226	0.264%	78.70067	12.70531	10.95922
187	217	0.253%	75.56657	12.19935	10.52279
188	209	0.244%	72.78071	11.7496	10.13486
189	201	0.235%	69.99484	11.29986	9.746919
190	194	0.226%	67.55721	10.90633	9.407474
191	187	0.218%	65.11958	10.5128	9.068029
192	181	0.211%	63.03018	10.17549	8.777076
193	173	0.202%	60.24432	9.725748	8.389139
194	167	0.195%	58.15492	9.388439	8.098186
195	161	0.188%	56.06552	9.05113	7.807234
196	156	0.182%	54.32435	8.770039	7.564773
197	151	0.176%	52.58319	8.488948	7.322312
198	146	0.170%	50.84202	8.207857	7.079852
199	142	0.166%	49.44909	7.982984	6.885883
200	138	0.161%	48.05616	7.758111	6.691914
201	134	0.156%	46.66323	7.533238	6.497946
202	130	0.152%	45.2703	7.308366	6.303977
203	126	0.147%	43.87736	7.083493	6.110009
204	123	0.144%	42.83266	6.914838	5.964532
205	120	0.140%	41.78797	6.746184	5.819056
206	117	0.137%	40.74327	6.577529	5.67358
207	115	0.134%	40.0468	6.465093	5.576595
208	112	0.131%	39.0021	6.296438	5.431119
209	110	0.128%	38.30563	6.184002	5.334135
210	107	0.125%	37.26094	6.015347	5.188658
211	106	0.124%	36.9127	5.959129	5.140166
212	104	0.121%	36.21624	5.846692	5.043182
213	102	0.119%	35.51977	5.734256	4.946198
214	101	0.118%	35.17154	5.678038	4.897706
215	99	0.116%	34.47507	5.565602	4.800721
216	98	0.114%	34.12684	5.509383	4.752229

Table D-1. Sediment Total Maximum Daily Loads for Prospect Creek, Clear Creek, and Dry Creek

Calendar Day	Mean Discharge	Percent of Annual Flow	TMDL Prospect	TMDL Clear	TMDL Dry
217	96	0.112%	33.43037	5.396947	4.655245
218	94	0.110%	32.73391	5.284511	4.558261
219	93	0.109%	32.38567	5.228292	4.509768
220	91	0.106%	31.68921	5.115856	4.412784
221	90	0.105%	31.34097	5.059638	4.364292
222	89	0.104%	30.99274	5.00342	4.3158
223	87	0.102%	30.29627	4.890983	4.218816
224	86	0.100%	29.94804	4.834765	4.170324
225	85	0.099%	29.59981	4.778547	4.121831
226	84	0.098%	29.25158	4.722329	4.073339
227	83	0.097%	28.90334	4.66611	4.024847
228	82	0.096%	28.55511	4.609892	3.976355
229	81	0.095%	28.20688	4.553674	3.927863
230	80	0.093%	27.85864	4.497456	3.879371
231	79	0.092%	27.51041	4.441238	3.830879
232	78	0.091%	27.16218	4.385019	3.782386
233	77	0.090%	26.81394	4.328801	3.733894
234	76	0.089%	26.46571	4.272583	3.685402
235	76	0.089%	26.46571	4.272583	3.685402
236	75	0.088%	26.11748	4.216365	3.63691
237	74	0.086%	25.76925	4.160147	3.588418
238	73	0.085%	25.42101	4.103928	3.539926
239	72	0.084%	25.07278	4.04771	3.491434
240	72	0.084%	25.07278	4.04771	3.491434
241	71	0.083%	24.72455	3.991492	3.442942
242	70	0.082%	24.37631	3.935274	3.394449
243	69	0.081%	24.02808	3.879056	3.345957
244	69	0.081%	24.02808	3.879056	3.345957
245	68	0.079%	23.67985	3.822837	3.297465
246	68	0.079%	23.67985	3.822837	3.297465
247	67	0.078%	23.33161	3.766619	3.248973
248	66	0.077%	22.98338	3.710401	3.200481
249	66	0.077%	22.98338	3.710401	3.200481
250	65	0.076%	22.63515	3.654183	3.151989
251	65	0.076%	22.63515	3.654183	3.151989
252	64	0.075%	22.28691	3.597965	3.103497
253	64	0.075%	22.28691	3.597965	3.103497
254	63	0.074%	21.93868	3.541746	3.055004
255	62	0.072%	21.59045	3.485528	3.006512
256	62	0.072%	21.59045	3.485528	3.006512

Table D-1. Sediment Total Maximum Daily Loads for Prospect Creek, Clear Creek, and Dry Creek

Calendar Day	Mean Discharge	Percent of Annual Flow	TMDL Prospect	TMDL Clear	TMDL Dry
257	61	0.071%	21.24222	3.42931	2.95802
258	61	0.071%	21.24222	3.42931	2.95802
259	61	0.071%	21.24222	3.42931	2.95802
260	60	0.070%	20.89398	3.373092	2.909528
261	60	0.070%	20.89398	3.373092	2.909528
262	60	0.070%	20.89398	3.373092	2.909528
263	59	0.069%	20.54575	3.316874	2.861036
264	59	0.069%	20.54575	3.316874	2.861036
265	58	0.068%	20.19752	3.260655	2.812544
266	58	0.068%	20.19752	3.260655	2.812544
267	57	0.067%	19.84928	3.204437	2.764052
268	56	0.065%	19.50105	3.148219	2.715559
269	56	0.065%	19.50105	3.148219	2.715559
270	56	0.065%	19.50105	3.148219	2.715559
271	55	0.064%	19.15282	3.092001	2.667067
272	55	0.064%	19.15282	3.092001	2.667067
273	55	0.064%	19.15282	3.092001	2.667067
274	54	0.063%	18.80458	3.035783	2.618575
275	55	0.064%	19.15282	3.092001	2.667067
276	54	0.063%	18.80458	3.035783	2.618575
277	54	0.063%	18.80458	3.035783	2.618575
278	54	0.063%	18.80458	3.035783	2.618575
279	53	0.062%	18.45635	2.979564	2.570083
280	53	0.062%	18.45635	2.979564	2.570083
281	53	0.062%	18.45635	2.979564	2.570083
282	53	0.062%	18.45635	2.979564	2.570083
283	53	0.062%	18.45635	2.979564	2.570083
284	53	0.062%	18.45635	2.979564	2.570083
285	54	0.063%	18.80458	3.035783	2.618575
286	56	0.065%	19.50105	3.148219	2.715559
287	57	0.067%	19.84928	3.204437	2.764052
288	56	0.065%	19.50105	3.148219	2.715559
289	55	0.064%	19.15282	3.092001	2.667067
290	55	0.064%	19.15282	3.092001	2.667067
291	54	0.063%	18.80458	3.035783	2.618575
292	54	0.063%	18.80458	3.035783	2.618575
293	53	0.062%	18.45635	2.979564	2.570083
294	53	0.062%	18.45635	2.979564	2.570083
295	53	0.062%	18.45635	2.979564	2.570083
296	53	0.062%	18.45635	2.979564	2.570083

Table D-1. Sediment Total Maximum Daily Loads for Prospect Creek, Clear Creek, and Dry Creek

Calendar Day	Mean Discharge	Percent of Annual Flow	TMDL Prospect	TMDL Clear	TMDL Dry
297	53	0.062%	18.45635	2.979564	2.570083
298	53	0.062%	18.45635	2.979564	2.570083
299	53	0.062%	18.45635	2.979564	2.570083
300	53	0.062%	18.45635	2.979564	2.570083
301	53	0.062%	18.45635	2.979564	2.570083
302	53	0.062%	18.45635	2.979564	2.570083
303	53	0.062%	18.45635	2.979564	2.570083
304	54	0.063%	18.80458	3.035783	2.618575
305	55	0.064%	19.15282	3.092001	2.667067
306	54	0.063%	18.80458	3.035783	2.618575
307	56	0.065%	19.50105	3.148219	2.715559
308	60	0.070%	20.89398	3.373092	2.909528
309	64	0.075%	22.28691	3.597965	3.103497
310	63	0.074%	21.93868	3.541746	3.055004
311	62	0.072%	21.59045	3.485528	3.006512
312	61	0.071%	21.24222	3.42931	2.95802
313	60	0.070%	20.89398	3.373092	2.909528
314	62	0.072%	21.59045	3.485528	3.006512
315	62	0.072%	21.59045	3.485528	3.006512
316	66	0.077%	22.98338	3.710401	3.200481
317	75	0.088%	26.11748	4.216365	3.63691
318	74	0.086%	25.76925	4.160147	3.588418
319	72	0.084%	25.07278	4.04771	3.491434
320	71	0.083%	24.72455	3.991492	3.442942
321	71	0.083%	24.72455	3.991492	3.442942
322	70	0.082%	24.37631	3.935274	3.394449
323	69	0.081%	24.02808	3.879056	3.345957
324	68	0.079%	23.67985	3.822837	3.297465
325	68	0.079%	23.67985	3.822837	3.297465
326	70	0.082%	24.37631	3.935274	3.394449
327	72	0.084%	25.07278	4.04771	3.491434
328	80	0.093%	27.85864	4.497456	3.879371
329	92	0.107%	32.03744	5.172074	4.461276
330	126	0.147%	43.87736	7.083493	6.110009
331	129	0.151%	44.92206	7.252147	6.255485
332	113	0.132%	39.35033	6.352656	5.479611
333	102	0.119%	35.51977	5.734256	4.946198
334	109	0.127%	37.9574	6.127783	5.285643
335	148	0.173%	51.53849	8.320293	7.176836
336	130	0.152%	45.2703	7.308366	6.303977

Table D-1. Sediment Total Maximum Daily Loads for Prospect Creek, Clear Creek, and Dry Creek

Calendar Day	Mean Discharge	Percent of Annual Flow	TMDL Prospect	TMDL Clear	TMDL Dry
337	121	0.141%	42.1362	6.802402	5.867548
338	130	0.152%	45.2703	7.308366	6.303977
339	139	0.162%	48.40439	7.814329	6.740407
340	140	0.163%	48.75263	7.870548	6.788899
341	122	0.142%	42.48443	6.85862	5.91604
342	110	0.128%	38.30563	6.184002	5.334135
343	103	0.120%	35.868	5.790474	4.99469
344	98	0.114%	34.12684	5.509383	4.752229
345	98	0.114%	34.12684	5.509383	4.752229
346	100	0.117%	34.8233	5.62182	4.849213
347	105	0.123%	36.56447	5.902911	5.091674
348	110	0.128%	38.30563	6.184002	5.334135
349	114	0.133%	39.69857	6.408874	5.528103
350	114	0.133%	39.69857	6.408874	5.528103
351	110	0.128%	38.30563	6.184002	5.334135
352	106	0.124%	36.9127	5.959129	5.140166
353	106	0.124%	36.9127	5.959129	5.140166
354	103	0.120%	35.868	5.790474	4.99469
355	99	0.116%	34.47507	5.565602	4.800721
356	96	0.112%	33.43037	5.396947	4.655245
357	95	0.111%	33.08214	5.340729	4.606753
358	108	0.126%	37.60917	6.071565	5.23715
359	112	0.131%	39.0021	6.296438	5.431119
360	106	0.124%	36.9127	5.959129	5.140166
361	124	0.145%	43.1809	6.971056	6.013025
362	136	0.159%	47.35969	7.645675	6.59493
363	118	0.138%	41.0915	6.633747	5.722072
364	104	0.121%	36.21624	5.846692	5.043182
365	99	0.116%	34.47507	5.565602	4.800721
366	97	0.113%	33.77861	5.453165	4.703737

APPENDIX E
FISHERIES AND OTHER AQUATIC LIFE

Fisheries Overview

The Prospect Creek fish community was originally comprised of nine native species, with bull trout (*Salvelinus confluentus*) and westslope cutthroat trout (*Oncorhynchus clarki lewisi*) the representative char and trout species. Fish introductions in the Lower Clark Fork River and directly into Prospect Creek have increased fish community diversity (**Table E-1**). Introduced species including rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and brook trout (*Salvelinus fontinalis*) have affected this native fish assemblage through competition, hybridization, and predation.

Table E-1. Native and Introduced Fish Species Sampled in Prospect Creek

Native Fish Species	Introduced Fish Species
Bull trout	Rainbow trout (Pre-1919)
Westslope cutthroat trout	Brown trout (1945)
Largescale sucker	Brook trout (Pre-1913)
Northern pikeminnow	
Longnose dace	
Longnose sucker	
Slimy sculpin	
Mountain whitefish	
Peamouth	

Introduction dates from Pratt and Huston (1993).

Bull Trout and Westslope Cutthroat Trout

Bull trout, a federally listed threatened species (USDI, 1998), and westslope cutthroat trout recognized by the State of Montana as a Species of Special Concern (Roedel, 1999), are less numerous today than they were historically in the Lower Clark Fork River and Prospect Creek. The construction of Thompson Falls Dam, Noxon Rapids Dam, and the Cabinet Gorge Dam on the Clark Fork River likely affected the distribution and size of native fish populations utilizing Prospect Creek. Anecdotal accounts indicate that the two species were more abundant in the Prospect Creek watershed prior to widespread timber harvest, power line and gas pipeline construction, and habitat modifications (Pratt and Huston, 1993). Historical accounts by local residents suggest bull trout were once numerous in the watershed, with the 1949 bull trout spawning run numbering approximately 100 fish (Pratt and Huston, 1993). Other unverified and anecdotal accounts placed the number of spawning adults closer to 400 fish (Pratt and Huston, 1993). Bull trout were once numerous enough that local residents poached fish using dynamite caps affixed to the ends of long sticks and also spear-snagged fish from horseback (Pratt and Huston, 1993).

The introduction of several fish species has also affected the native fish community through competition, predation, and possibly hybridization. Introductions of brown trout, rainbow trout and brook trout in the early twentieth century may have also impacted the native fish assemblage in Prospect Creek. Brook trout and bull trout spawning periods overlap, commonly resulting in

hybridization, although none have been observed in Prospect Creek (WWP, 1996, Katzman, 2003). Brown trout likely compete with bull trout at several life stages and also may superimpose on bull trout redds during spawning due to brown trout spawning occurring later than bull trout (Moran et. al., 2003). Bull trout and brook trout may also compete with bull trout at earlier life stages. Introduced rainbow trout populations commonly hybridize and compete with native westslope cutthroat trout which is likely occurring lower in the Prospect Creek drainage and possibly higher in the drainage (WWP, 1996). Introduced species interactions in the Noxon Reservoir likely also increase the risk of predation and competition. Introduced species found in Noxon Reservoir which may be impacting native bull and westslope cutthroat trout include northern pike, largemouth bass, smallmouth bass, walleye, rainbow trout, and brown trout (Liermann and Tholl, 2003).

The Prospect Creek drainage is considered core habitat for bull trout (MBTRT, 2000) and was proposed by the U.S. Fish and Wildlife Service (2002) as critical bull trout habitat. Tributaries such as Clear Creek and Wilkes Creek potentially provide important habitat for westslope cutthroat trout and bull trout. Bull trout are believed to have inhabited Clear Creek and Wilkes Creek in the past (Pratt and Huston, 1993). However, the current distribution of bull trout in these subwatersheds is unknown at this time. Bull trout are not believed to have inhabited Dry Creek in the past (Pratt and Huston, 1993). Westslope cutthroat trout maintain a strong population in the drainage. Channel intermittency in the middle and lower watershed temporally limits upstream migration of fish from the lower to upper watershed during low flow periods. Within the Prospect Creek watershed, bull trout and westslope cutthroat trout populations are Known Present Depressed in all stream segments except Cooper Gulch, which supports a strong westslope cutthroat population (USDA, 2000). Fish population status for Prospect Creek is included in **Table E-2**.

Table E-2. Status of Fish Populations in the Prospect Creek Watershed

6th Code HUC	Bull Trout	Westslope Cutthroat Trout	Rainbow Trout	Brown Trout	Brook Trout
Clear Creek	PD	D	PD	PP	S
Cooper Creek	S	S	PA	PA	PA
Crow Creek	D	D	PA	PA	PA
Dry Creek	PD	S	PD	P	PP
Lower Prospect	D	D	PD	S*	S
Upper Prospect	S*	S*	PD	PA	PD
Wilkes Creek	D	D	PA	PA	D

Reference: USDA 2000 and S. Moran, Avista, pers. comm. 2004
D = depressed, U = Unknown, S = Strong, PP = Presumed Present, PA = Presumed Absent, PD = Present Depressed, PS = Present Strong, P = Present
* Liermann et al. 2003

Fish Population Summary

Quantitative fish population estimates have been completed on Prospect Creek since the early 1990s when a cooperative effort that included WWP (Washington Water Power Company), MFWP, and USFS completed an electorfishing study (WWP, 1996). In 2000, Montana Fish, Wildlife & Parks conducted an in-depth study to document the status and life history strategies

employed by bull trout and westslope cutthroat trout inhabiting Prospect Creek (Katzman, 2003). Electrofishing and redd counts are replicated biannually by MFWP and Avista on three reaches of Prospect Creek.

The sampling results from 1992 through 1994 suggested fish populations are limited by channel instability, dewatering, infrequent woody debris accumulations, and poor spawning and rearing habitat conditions. Stable reaches supporting complex aquatic habitats had higher fish counts (WWP, 1996). Monitoring results suggest Prospect Creek supports migratory and possibly resident life history forms of native bull trout and westslope cutthroat trout, in addition to similar life history forms of introduced salmonids including brown trout and rainbow trout. Resident brook trout were also present in the watershed (MFWP, 2003).

Bull Trout

Redd counts completed since 1993 suggest Prospect Creek is an important bull trout spawning tributary in the Lower Clark Fork River (WWP, 1996 and Katzamn, 2003). The presence of large redds were identified in the perennial reach of Prospect Creek in 2000 (1 migratory fish), 2001 (6 redds), and 2002 (4 redds). Redd surveys were typically completed prior to the end of bull trout spawning (Katzman, 2003). Survey timing may have resulted in an incomplete sampling of bull trout redds.

Bull trout population estimates based on electrofishing results approximated between 4.9 and 30.4 bull trout per 100m in upper Prospect Creek (WWP, 1996 *as cited in* Katzman, 2003). Low numbers of juvenile bull trout outmigrating from the watershed may indicate low bull trout reproductive success in the watershed. However, low estimates may also be related to poor trap efficiency due to trap avoidance by outmigrating juvenile bull trout and marginal sampling effort (Katzman, 2003). Bull trout embryo survival was considered moderate relative to other tributaries in the LCF (WWP, 1996).

Although not directly comparable due to differences in sampling locations, the MFWP electrofishing surveys yielded fish population estimates similar to the WWP (1996) surveys. Upper Prospect Creek bull trout estimates remained similar from 1999 to 2002, annually varying from 4.9 to 37.0 fish per 100 m (Katzman, 2003). These results were similar to bull trout densities in other tributaries to the Lower Clark Fork River (Katzman, 2003).

Westslope Cutthroat Trout

Electrofishing population estimates conducted in 1999 were similar to the WWP (1996) results. Westslope cutthroat trout populations in the WWP investigations ranged from 56.5 to 59.7 fish per 100 m. The MFWP survey estimated 34.2 to 60.7 fish per 100 m. Although the WWP and MFWP surveys were not completed in the same sample reaches and the results are not directly comparable, the westslope cutthroat population estimates in upper Prospect Creek was similar between the two surveys (MFWP, 2003). In general, westslope cutthroat trout density estimates appear to be similar to densities observed in other tributaries of the Lower Clark Fork River drainage during 2000, 2001, and 2002 (Katzman, 2003).

Other Species

Rainbow trout dominated the majority of the trout and char greater than 40 mm total length (TL) sampled by a rotary screw trap used to sample emigrating juveniles in 2000 and 2001 (Katzman and Tholl, 2003). From march to July, rainbow trout greater than 40 mm TL comprised 50% of trout captured by the screw trap in 2000, and 65% of trout captured by the trap in 2001 (Katzman, 2003). Rainbow trout were not sampled during electrofishing investigations in upper Prospect Creek.

Brown trout comprised 29% of the trout and char greater than 40 mm TL sampled by the rotary screw trap in 2000, and 16% in 2001 (Katzman and Tholl, 2003). Many unidentifiable age-0 salmonids sampled in the spring by the rotary trap may have been larval brown trout. Brown trout were not surveyed in upper Prospect Creek during the electrofishing projects from 1999 to 2002.

Aquatic Macroinvertebrates

Several studies have sampled aquatic macroinvertebrate in Prospect Creek and its tributaries.

- The USFS PIBO study (PACFISH/INFISH Biological Opinion Effectiveness Monitoring Program) collected and analyzed aquatic macroinvertebrate samples in Cooper Creek and Dry Creek in 2002. These data were further analyzed by DEQ for this document.
- Montana DEQ collected and analyzed samples in Clear and Dry Creeks in 2003 and
- WWP collected and analyzed aquatic macroinvertebrate samples in Prospect and Crow Creeks in 1994. These data were further analyzed by DEQ for this document.

Summary values and indices include average species richness, average percent EPT assemblage, average Shannon's diversity index, Hilsenhoff Biological Index (HBI), and the mountain ecoregion index of biological integrity (mountain IBI) used by DEQ as an indication of impairment to aquatic life. Species richness is reported as the average number of different taxa. Average percent EPT is the percent of the sample which consists of mayflies, caddisflies, and true flies (ephemeroptera, trichoptera, and diptera). Percent EPT values range from 0 to 100. The higher the percent EPT, generally the healthier the aquatic invertebrate community as most EPT species are typically considered sensitive to pollution and also make up a significant part of salmonid diet. Average Shannons' diversity index accounts for species abundance and how evenly species are distributed. In the sites sampled, values range from 2.07 to 3.33, with values around 2.0 indicating moderate diversity and some potential impact to the aquatic invertebrate community, and 3.0 or higher indicating a more desired condition. The Hilsenhoff Biological Index, using species level data, indicates pollution tolerance levels. HBI values range from 0 to 10, 0 indicating no impairment (intolerant species) and 10 indicating impairment (tolerant species). Mountain IBI is a comparison of multiple sample metrics to reference condition streams in the mountain ecoregion, assuming reference conditions are 100% (Bukantis, 1998). For mountain IBI, values greater than 75% indicate full support of aquatic life, 25-75% indicates partial support of aquatic life, and less than 25% indicate non-support of aquatic life. Note that an indication of partial or non-support for aquatic life (macroinvertebrate in this situation) can also be an indicator of partial or non-support of a cold-water fishery since the water quality conditions impacting the aquatic life can also impact cold-water fish, and the impacted macroinvertebrate populations can also impact the food supply for cold-water fish. An indication

of full support for aquatic life can also be an indicator of full support for cold-water fish although there are habitat and other water quality type conditions that could have negative impacts on cold water fish but not necessarily impact macroinvertebrates enough to indicate impairment using the mountain IBI. **Table E-3** summarizes the select values and indices of these various studies.

In the 2002 PIBO study of Cooper and Dry Creeks (USFS, 2003), data were collected for two reaches in each stream. Species richness and percent EPT in Cooper Creek are moderate to high (richness: 13 and 21 and EPT 77%). HBI values were low (2.09, 1.82) and mountain IBI values were moderate (67%).

For Dry Creek, species richness and percent EPT were low (richness: 9 and 13, EPT: 25% and 5%). HBI was low (2.16 and 1.98) and mountain IBI was low (46% and 42%). These data, particularly the mountain IBI, indicate impairment in both Cooper and Dry creeks, although the impairment does not suggest a metals problem. USFS macroinvertebrate data collection methods vary from those used by Montana DEQ. USFS data identifies midges to the subfamily level and, therefore, midge numbers are underestimated. (D. Feldman, pers. comm., 2005).

The 2003 Montana DEQ assessment of macroinvertebrates conducted by Bollman (2003) indicate full use support of aquatic life at both Clear Creek sites and partial to non-support of aquatic life at the Dry Creek site.

At the upper Clear Creek site, species richness, percent EPT and Shannon’s diversity index were all high (44, 82%, and 3.33, respectively) (**Table E-3**). HBI was low (1.48) and mountain IBI was high (90%). Based on the DEQ assessment files, findings suggest excellent water quality and substrates free from fine sediment deposition, reach-scale habitat features such as bank stability, riparian integrity, and channel morphology were intact. Flow was perennial and substrate scouring sediment pulses or toxic inputs were absent. The only metric reducing the DEQ score was a relatively low percentage of scrapers and shredders (26% of fauna). No sediment tolerant taxa were present and 3 sediment sensitive taxa identified. One-half of the fauna identified were cold stenotherm taxa. The metals tolerance index was low (1.54).

At the lower Clear Creek site, species richness, percent EPT and Shannon’s diversity index were all relatively high (39, 78%, and 3.10 respectively). HBI was low (2.29). Mountain IBI was also relatively high (81%). The number of sensitive taxa was slightly reduced and the percent of filterers was slightly elevated. Percent scapers and shredders was very low (14%). One sediment tolerant taxa and 2 sediment sensitive taxa were identified. Twelve percent of the fauna identified were cold stenotherm taxa. The metals tolerance index was low (1.54). These indicators at lower Clear Creek site suggest high water quality.

At the Dry Creek site, species richness was moderate (22), percent EPT was low (5%), and Shannon’s diversity index was moderate (2.07). HBI was moderate (3.98) and mountain IBI was low (29%). There was only one sensitive taxa identified and percent filterers was slightly elevated. Percent tolerant taxa was very low. Midges dominated the sample, and non-insect made up the next most abundant group. There was a low number of clingers (6 taxa) and caddislfly larvae (3 taxa). This suggests fine sediment may compromise the substrate. The assemblage was "overwhelmed" by gatherers which typically indicates water quality degradation. Low taxa

richness may indicate monotonous habitats. The biotic index was somewhat elevated (3.98) and the metals tolerance index value was high (6.35). The high metals index coupled with the finding of a single heptageniid mayfly suggest the potential for metals pollution. Other possible disturbances include fine sediment deposition and disruption of reach-scale habitat features such as unstable streambanks, loss of riparian zone function, or disturbance of natural channel components. These indicators suggest partial to non-support of aquatic life in Dry Creek.

Table E-3. Aquatic Macroinvertebrate Summary Statistics for Prospect Creek Watershed

Reach	Data Source	Species Richness (Ave.)	Percent EPT (Ave.)	Shannon's Diversity Index (Ave.)	HBI (Ave.)	Mountain IBI (Ave.)*
Clear Lower	DEQ 2003	39	78%	3.10	2.29	81%
Clear Upper	DEQ 2003	44	82%	3.33	1.48	90%
Cooper 19630	PIBO 2002	21	77%	--	2.09	67%
Cooper 123107	PIBO 2002	13	77%	--	1.82	67%
Crow 1	WWP 1996+	8	45%	--	8.75	36%
Crow 2	WWP 1996+	9	91%	--	2.05	59%
Dry 123109	PIBO 2002	9	25%	--	2.16	46%
Dry 119632	PIBO 2002	13	28%	--	1.98	42%
Dry	DEQ 2003	22	5%	2.07	3.98	29%
Prospect Creek Average	WWP 1996+	22	84%	2.77	--	--
Prospect 1	WWP 1996+	11	85%	--	3.23	52%
Prospect 2	WWP 1996+	14	77%	--	3.89	41%
Prospect 4	WWP 1996+	14	77%	--	5.49	41%
Prospect 5	WWP 1996+	10	88%	--	3.23	46%
Prospect 6	WWP 1996+	10	93%	--	3.18	49%
Prospect 7	WWP 1996+	8	96%	--	2.47	52%

*Multimetric index based on the mountain ecoregion IBI method described in Bukantis 1998.
+ Additional analysis performed by DEQ.

In the WWP study (1996), which sampled mainstem Prospect Creek and Crow Creek, taxa were identified to the family level and some to the generic level. As a result only general conclusions may be drawn from this data (D. Feldman, pers. comm., 2005). Samples were dominated by ephemeroptera (mayflies, 39 percent), trichoptera (caddisflies, 34 percent), and diptera (flies, 14 percent). In general, species richness was relatively high (22), percent EPT was also high (84%), and Shannon's diversity index was relatively low (2.77) compared to other macroinvertebrate communities in other tributaries in the Lower Clark Fork River drainage (WWP, 1996).

In 2005, Montana DEQ re-analyzed 1994 macroinvertebrate data summarized in WWP 1996 for Crow and Prospect creeks. Species richness in Prospect Creek was low to moderate (8-14) while percent EPT was moderate to high (77-96%). Shannon's diversity index was not calculated for the Prospect Creek sites. HBI values were moderate for all Prospect Creek sites, ranging from 3.47 to 5.48, with an average of 3.58. Mountain IBI for all Prospect Creek sites fell into the 25-75% partial support category with values ranging from 41-52% (**Table E-3**). These data for Prospect Creek suggest possible impairment conditions.

In Crow Creek, species richness was low at both sites (8-9), and percent EPT was low at site 1 (45%) and high at site 2 (91%). Shannon's diversity index was not calculated for the Crow Creek sites. HBI values were very high at site 1 (8.75) and low at site 2 (2.05). Mountain IBI values

were low at site 1 (36%) and moderate at site 2 (59%). These data for Crow Creek suggest partial impairment at site 2 and possibly non-support at site 1.

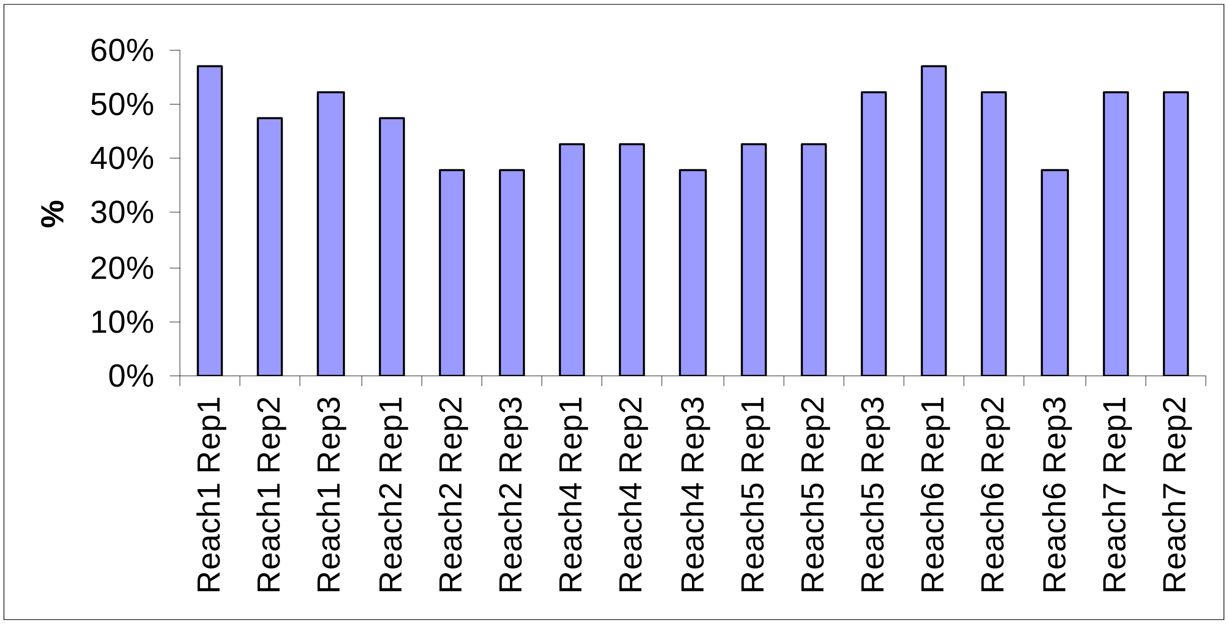


Figure E-1. Mountain IBI Values for Prospect Creek Data Collected in 1994 and Re-Analyzed by Montana DEQ in 2005
Reference: WWP 1996

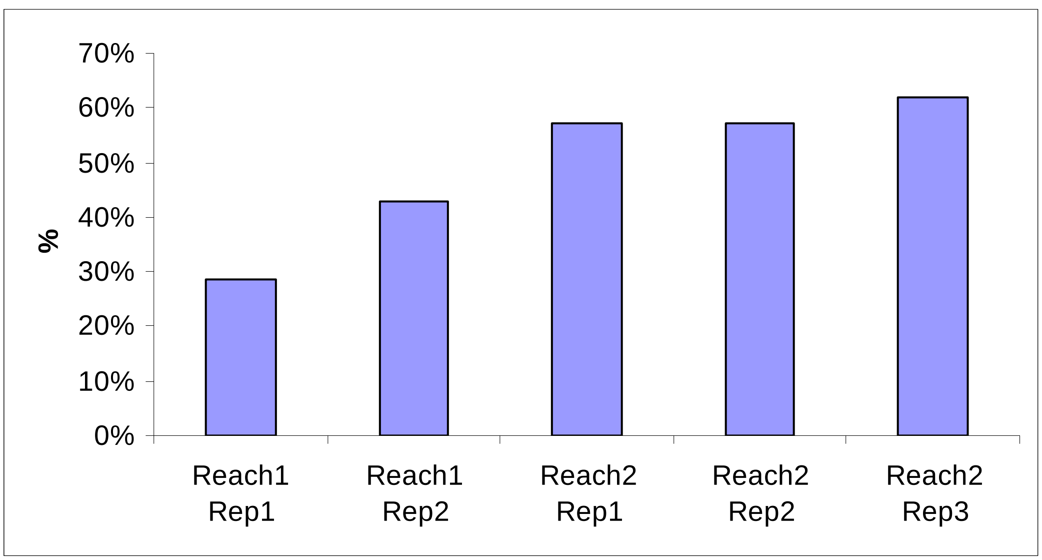


Figure E-2. Mountain IBI Values for Crow Creek Data Collected in 1994 and Re-Analyzed by Montana DEQ in 2005
Reference: WWP 1996

Primary Productivity and Periphyton

Primary productivity and periphyton were evaluated in two studies, WWP (1996) and Bahls (2004). WWP examined periphyton and chlorophyll a production in Prospect and Crow creeks. Bahls assessed biological integrity via algal assemblages and diatom matrices in Clear and Dry creeks.

The WWP study quantified periphyton in Prospect and Crow creek samples after growing for 39 days on artificial substrates. The average autotrophic index was relatively low while the chlorophyll *a* production and net productivity were high compared to other tributaries in the Lower Clark Fork River (WWP, 1996).

Table E-4. Primary Productivity Summary Statistics for Prospect Creek

Parameter	Average	Relative to Other LCFR Tributaries
Ave. Autotrophic Index	3.64	Low
Chlorophyll a (mg/m2)	3.94	High
Net Productivity (mg/m2/day)	0.75	High

Reference: WWP 1996

The 2003 Montana DEQ assessment of periphyton conducted by Bahls (2004) found that periphyton in both Clear and Dry creek indicate “good to excellent biological integrity”, “no impairment”, and “full support of aquatic life uses”. Sediment, organic and temperature indicators were slightly elevated at the lower Clear Creek site. Other stressors indicated by the results for the lower Clear Creek site were attributed to natural causes. Sites on Dry Creek and upper Clear Creek supported coldwater algal floras. Inorganic nutrients were slightly elevated at the Dry Creek site whereas organic nutrients were slightly elevated at the upper Clear Creek site. For all sites, periphyton indicator levels did not exceed impairment indicator thresholds

References

Bahls, L. 2004. Biological integrity of Clear Creek and Dry Creek near Thompson Falls, MT based on the structure and composition of the benthic algae community. A report prepared by , Helena, MT: Hannaea.

Bollman, W. 2003. A Biological Assessment of Sites on Clear Creek and Dry Creek: Sanders County, Montana. Missoula, MT: Rhithron and Associates.

Bollman, W. 1998. Improving Stream Bioassessment Methods for the Montana Valleys and Foothill Prairies Ecoregion. Master's Thesis (MS). Missoula, MT: University of Montana.

Bukantis, R. 1998. Rapid Bioassessment macroinvertebrate Protocols: Sampling and Sample Analysis SOP's. Working Draft, Helena, Montana: Montana, Department of Environmental Quality.

Feldman, David. 2005. Email to Dean Yashan regarding analysis of WWP macroinvertebrate data.

Katzman, Laura. 2003. Prospect Creek Westslope Cutthroat Trout and Bull Trout Life History Study Final Report - 2000: Fish Passage/Native Salmonid Program, Appendix C. Spokane, WA: Avista, Corporation.

Katzman, Laura, T. D. Tholl. 2003. Habitat Restoration Monitoring Annual Progress Report - 2001 : Montana Tributary Habitat Acquisition and Recreational Fishery Enhancement Program, Appendix B. Thompson Falls, MT: Montana Fish, Wildlife and Parks.

Liermann, Brad W. L. Katzman; T. D. Tholl. 2003. Habitat Restoration Monitoring Comprehensive Report - 2001-2002 : Montana Tributary Habitat Acquisition and Recreational Fishery Enhancement Program, Appendix B. Thompson Falls, MT: Montana Fish, Wildlife and Parks.

Montana Bull Trout Restoration Team. 2000. Restoration Plan for Bull Trout in the Clark Fork River Basin and Kootenai River Basin Montana. Helena, Montana: Montana Bull Trout Restoration Team.

Montana Department of Environmental Quality. 2003. Reassessment Results. Unpublished Data.

Montana Department of Fish, Wildlife and Parks. 2003. Draft Environmental Assessment for the Reestablishment of a Bull Trout Fishery on Lake Koocanusa (Public Review Draft). Helena, MT: Montana Department of Fish, Wildlife and Parks.

Moran, Sean, C. Downs, R. Jakubowski. 2003. Lake Pend Oreille/Clark Fork River Fishery Research and Monitoring: Progress Report 1999 – 2001. Noxon, MT: Avista, Corporation

Pratt, Karen L.; J. E. Huston. 1993. Status of Bull Trout (Salvelinus confluentus) in Lake Pend Oreille and the Lower Clark Fork River : DRAFT. Spokane, WA: Washington Water and Power Company.

Roedel, M. D. 1999. Montana Animal Species of Special Concern. (Unpublished List). Helena, MT: Montana Natural Heritage Program.

U.S. Fish and Wildlife Service. 2002. Criteria Established for the Lake Koocanusa Core Area are Currently Being Met by the Grave Creek and Wigwam River Bull Trout Spawning Populations. Washington, D.C.: U.S. Fish and Wildlife Service.

U.S. Forest Service. 2000. Section 7 Consultation Watershed Baseline:Lower Clark Fork River, Montana. Libby, MT: U.S. Forest Service, Kootenai National Forest.

U.S. Forest Service. 1988. Lolo National Forest Land System Inventory. Missoula, MT: .U.S. Forest Service, Lolo National Forest.

U.S. Forest Service. PIBO. http://fsgeodata.fs.fed.us/pibo/.

Washington Water and Power. 1996. Lower Clark Fork River Tributary Survey: Final Report for a Cooperative Challenge Cost Share Project: Volume I of II. Spokane, WA: Washington Water and Power.

APPENDIX F
PHYSICAL STREAM CONDITION DATA INCLUDING COLLECTION AND ASSESSMENT METHODS

This appendix addresses existing fish habitat, channel morphology, and riparian vegetation conditions along with a general discussion on human activities and potential linkages between these activities and existing conditions. The focus is on non-point sources of pollution, links with riparian vegetation condition and stream morphology, and the relation of riparian and stream morphology conditions to land use practices in the Prospect Creek Watershed. Summarized data and data assessment methods provide the basis for the following discussion.

Existing Data and Watershed Assessments

In 2004 RDG reviewed existing data related to water quality and fish habitat in the Prospect Creek watershed. The existing information reviewed included fish habitat, channel morphology and upland assessments completed primarily by MFWP (Montana Fish Wildlife and Parks), WWP (Washington Water Power), and USFS (US Forest Service). Some of these data are integrated into the general watershed and stream characterization document (RDG, 2004), and some of this information is also presented below. Temperature data are presented in a separate appendix to this document (**Appendix I**). Metals data are presented in a separate document for the Prospect Creek Metals TMDL (DEQ, 2005).

Table F-1. Summary of Existing Biological, Chemical, and Physical Data Reviewed for Prospect Creek

Stream	Use	Biological	Chemical	Physical
Prospect Creek (18.9 miles from Headwaters to Mouth)	B-1	Fisheries Data (MFWP) Fisheries Data (WWP) Fisheries Data (Avista) Macroinvertebrates (WWP) Macroinvertebrates (DEQ)	Temperature (WWP) Temperature (DEQ)	Physical Data (DEQ) Physical Data (MFWP) Physical Data (USFS) Physical Data (WWP)

Reference: RDG, 2004

Fish Habitat Assessments

WWP (1996) quantified fish habitat conditions on Prospect Creek and other tributaries in the Lower Clark Fork River drainage. Prospect Creek was considered deficient in the evaluated habitat categories relative to comparable tributaries. Unlike other streams in the basin experiencing siltation effects, Prospect Creek was found to have low surface fine sediment accumulations. The following excerpt is from the WWP report:

> *"Fish habitat in Prospect Creek consists of primarily low gradient riffle and run habitat types; a substrate mix dominated by gravel and rubble; low amounts of fine sediment; a largely non-functional and altered riparian zone; a riparian vegetation mix consisting of a relatively even mix of vegetation types; and relatively low amounts of LWD." (WWP, 1996, p 201)*

USFS also conducted a fish habitat analysis for Prospect Creek in regard to bull trout habitat (USDA, 2000). Prospect Creek and several of its tributaries were classified primarily as "Functioning at Unacceptable Risk" or "Functioning at Risk" for most habitat quality indicators (**Table F-2**). Inadequate pool frequency, sediment, road density and sub-population size appeared to be the greatest limiting factors in the watershed based on the analysis. According to this analysis the integrated habitat indicator determination for all 6th Code HUC watersheds in Prospect Creek is Functioning at Unacceptable Risk. For the "sediment" habitat indicator, the analysis did not differentiate between coarse sediment (such as bed load) and fine sediment (such as wash load or suspended sediments).

Table F-2. Habitat Indicators for the Prospect Creek Watershed

6th Code HUC	Subpop Size	Water Temp	Sediment	Physical Barriers	Pool Frequency	Refugia	Road Density	Integrated
Clear Creek	FUR	FAR	FUR	FAR	FUR	FAR	FUR	FUR
Cooper Creek	FUR	FA	FAR	FAR	FUR	FAR	FAR	FUR
Crow Creek	FUR	FAR	FUR	FAR	FUR	FAR	FUR	FUR
Dry Creek	FUR	FA	FAR	FAR	FUR	FAR	FAR	FUR
Lower Prospect	FUR	FUR	FUR	FAR	FUR	FAR	FUR	FUR
Upper Prospect	FUR	FA	FAR	FUR	FUR	FAR	FAR	FUR
Wilkes Creek	FUR	FA	FAR	FUR	FAR	FAR	FAR	FUR
FUR = Functioning at Unacceptable Risk, FAR = Functioning at Risk, FA = Functioning Appropriately								

Reference: USDA, 2000

Pool Frequency

Methods

Pool frequency was evaluated in 2004 via two methods. The first method involved collecting a longitudinal profile for 2 segments of Clear, Crow, Cooper and Dry creeks and for Reaches 5 and 6 on mainstem Prospect Creek. Longitudinal profiles were approximately 20 bankfull widths in length. The number of pools and dimensions of pools were later derived from the longitudinal profiles. The second method involved a field count of the number of pools encountered within segments of mainstem Prospect Creek Reaches 2 through 4. The mid-point of each pool sampling segment corresponded to a cross section from the 2003 surveys. Each sample segment extended the length of 10 bankfull widths upstream and 10 bankfull widths downstream of the cross section location, for a total sample length of 20 times the bankfull width of the cross section. The number of pools and pool dimensions were recorded for each sample segment. For the second method, pools were defined as slack water features deeper than surrounding riffles. The approximate residual (base flow) width, depth and length of each pool were measured. It was also noted whether the pool was associated with rip rap or LWD. Pool frequency was calculated using the number of pools divided by the length of the sample segment **(Table F-3)**.

Results

Table F-3.Pool Frequency in the Prospect Creek Watershed

Water Body	Reach/ Cross Section	Surveyor	Sample Method	Rosgen Stream Type	# of Pools	Sample Length (feet)	Pools/ Mile
Main Stem	2/1	RDG	Field Count	D4	14	4228	17.5
Main Stem	2/2	RDG	Field Count	D4/C4	4	2042	10.3
Main Stem	2/3	RDG	Field Count	C4	4	1750	12.1
Main Stem	3/1	RDG	Field Count	C3	1	1234	4.3
Main Stem	3/2	RDG	Field Count	D4	6	3598	8.8
Main stem	3/3	RDG	Field Count	D4	5	2088	12.6
Main Stem	4/1	RDG	Field Count	D4	2	2360	4.5
Main Stem	4/2	RDG	Field Count	D3	4	1634	12.9
Main Stem	4/3	RDG	Field Count	D4b	4	1662	12.7
Main Stem	5 (FS R3&R4)	LNF	Long Profile	C	9	525	90.5
Main Stem	6 (FS R1)	LNF	Long Profile	B	7	634	58.3
Clear	3	RDG	Long Profile	C4	5	900	29.3
Clear	1	RDG	Long Profile	C4	3	1114	14.2
Clear	8 (FS R2b)	LNF	Long Profile	C	6	410	77.3
Crow	2	RDG	Long Profile	C4	6	900	35.2
Crow	1	RDG	Long Profile	C4	2	587	18.0
Cooper	3	RDG	Long Profile	C4/D4	6	965	32.8
Cooper	1	RDG	Long Profile	C/F	3	863	18.4
Dry	3	RDG	Long Profile	C4	8	900	46.9
Dry	1	RDG	Long Profile	C4	4	900	23.5

There is a notable difference in pool frequency values between mainstem Prospect reaches 5 and 6 and other mainstem Prospect reaches. This difference is attributable to two factors.

The first factor has to do with the size and order of the stream in reaches 5 and 6 which are located above Cooper Creek, Crow Creek and other major tributaries to Prospect Creek. Greater pool frequency can be expected in smaller, lower order streams compared to less frequent pools in larger, higher order main stem channels.

The second factor is channel type. Reaches 5 and 6 include C and B channel types whereas the dominant channel type of the downstream reaches is D. Greater pool frequency can be expected in reaches dominated by B and C channel type compared to lower pool frequency in D reaches characterized by aggradation.

LWD Frequency

Methods: TMDL Data

In July 2004, mainstem Prospect Creek and portions of Clear, Dry, Crow and Cooper creeks were inventoried for large woody debris distribution. A similar sampling scheme as used in the bank erosion inventory was also used for LWD sampling.

LWD was inventoried at a subsample of segments representing approximately 25% of the total stream length. For example, on the main stem, four-hundred foot bank lengths were sampled at 1200-foot intervals. (Sample 400’, walk 1200’ to start next 400’ sample segment). Tributary main stems and portions of their tributaries (Dry, Clear, Crow and Cooper Creeks) were also inventoried using a similar sampling method.

LWD was defined as pieces greater than 5 feet long and greater than 4 inches in diameter. For each subsample segment, all LWD pieces within the active bankfull channel, or on or near the stream bank which could be contributed to the active channel in a bankfull or greater event, were tallied by size class. LWD criteria, including size classes are described in **Tables F-4 and F-5**.

Table F-4. Size Classes of Single Pieces of LWD

	Length Range (feet)	**Diameter Range (feet)**
Very Small	5 - 16	0.3 – 1.0
Small	16-50	1.0-2.5
Medium	>50	1.0-2.5
Large	16-50	> 2.5
Very Large	> 50	> 2.5

Qualifying pieces of LWD in groups of 2 or more were counted as aggregates. The number of aggregates within each subsample segment was tallied. For each aggregate, the approximate number of individual pieces was recorded along with the height, width, length of the aggregate and the approximate percent of the aggregate mass consisting of voids (for estimating total volume of wood). (**Table F-5**).

Table F-5. Large Woody Debris Count Criteria

LWD Category	**Criteria**	
LWD Singles	> 5 feet long AND > 4 inches in diameter	Number of qualifying pieces by size class
LWD Aggregates	2 or more pieces entangled > 5 feet long AND > 4 inches in diameter	Number of pieces in aggregate, aggregate dimensions (height, width, length) and percent void space

Location and function of the LWD were also noted. Location descriptions included "in-channel" and "recruitable". In-channel pieces were located within the channel at or below the bankfull elevation. Recruitable pieces were defined as those pieces at or near the stream bank which could be contributed to the active channel in a bankfull or greater event. Noted functions of LWD included bank protection, bank erosion, pool forming, channel forming, and bar storage.

The numbers of sampled single LWD pieces and LWD aggregates per channel length were calculated for each reach. It was assumed that the 25% sub sample provided a representative sample of LWD throughout each reach. Results are presented in **Table F-6**.

Results: TMDL Data

Table F-6. LWD Frequency in the Prospect Creek Watershed (2004)*

Water Body	Reach	Stream Type	Sampling Length	# Singles 5-16'	# Singles > 16'	# Aggregates	Total (Aggregates + Singles > 5')	Total Per Mile (Aggregates + Singles > 5')	Total (Aggregates + Singles > 16')	Total Per Mile (Aggregate + Singles > 16')
Main Stem	R1	B3/F3	--	--	--	--	--	--	--	--
Main Stem	R2	D4/C4	6400	70	145	43	258	213	188	155
Main Stem	"Ref" C	Ref C4	--	--	--	--	--	--	--	--
Main Stem	R3	D4/C4	8400	35	120	66	221	139	186	117
Main Stem	R4	D4/3	4800	54	103	54	211	232	157	173
Main Stem	R5, (FS R3)	C	2400	24	32	22	78	172	54	119
Main Stem	R6	B	--	--	--	--	--	--	--	--
Clear Creek	R1	C4	900	6	15	7	28	164	22	129
Clear Creek	R2	B4c/F4b	600	3	4	2	9	79	6	53
Clear Creek	R3	C4	3300	50	5	50	105	168	55	88
Clear Creek	R4	D4	1200	14	12	17	43	189	29	128
Clear Creek	R1	C4/D4	900	18	3	7	28	164	10	59
Clear Creek	R2	C4/D4	600	5	0	5	10	88	5	44
Clear Creek	R3	C4/D4	--	--	--	--	--	--	--	--
Clear Creek	R4	C4/D4	--	--	--	--	--	--	--	--
Clear Creek	R5	F3	--	--	--	--	--	--	--	--
Clear Creek	R6	C3/D4	--	--	--	--	--	--	--	--
Clear Creek	R7	B3/C3	--	--	--	--	--	--	--	--
Clear Creek	R8	C	--	--	--	--	--	--	--	--
Clear Creek	R9	A/B	--	--	--	--	--	--	--	--
Dry Creek	R1	C4	1500	17	22	21	60	211	43	151
Dry Creek	R2	A3	900	20	9	3	32	188	12	70
Dry Creek	R3	C4	2400	17	37	25	79	174	62	136
Dry Creek	R4, WF	D4b/B4	300	5	2	2	9	158	4	70
Dry Creek	R4, EF	D4b/C4	1500	15	8	11	34	120	19	67
Wilkes Creek	R1	B4c	--	--	--	--	--	--	--	--
Wilkes Creek	R2	C4	--	--	--	--	--	--	--	--
Wilkes Creek	R3	B4c	--	--	--	--	--	--	--	--
Wilkes Creek	R2, (FS R1)	C4	--	--	--	--	--	--	--	--
Wilkes Creek	R3, (FS R2)	C4	--	--	--	--	--	--	--	--

Crow Creek	R1	C3/4	1500	14	14	14	42	148	28	99
Crow Creek	R2	C3/4	900	1	9	16	26	153	25	147
Crow Creek	R1, EF	C4b	900	13	30	15	58	340	45	264
Crow Creek	R1, WF	C4b	900	2	9	20	31	182	29	170
Cooper Creek	R1	F3	300	6	6	2	14	246	8	141
Cooper Creek	R2	B3c	600	3	7	4	14	123	11	97
Cooper Creek	R3	C4/D4	1500	11	9	8	28	99	17	60
Cooper Creek	R4	C4/B	1200	3	13	13	29	128	26	114
Cooper Creek	R5	B4/C	600	2	4	3	9	79	7	62
Cooper Creek	R6	C4/B	300	0	0	1	1	18	1	18
Cooper Creek	R7	B4 to C4	600	1	4	3	8	70	7	62
Cooper Creek	R8	A	--	--	--	--	--	--	--	--
*Includes in-channel and recruitable LWD.										

Methods: Other Data

LWD was also inventoried on mainstem of Prospect Creek by WWP in 1996 and by Watershed Consulting in 1999. WWP also inventoried LWD on Crow Creek in 1996. WWP counted LWD singles, aggregates and rootwads with diameter greater than 0.1 meter within the bankfull channel. Differentiation was made between small woody debris (< 3 m in length) and large woody debris (> 3 m in length). Root wads with stems less than 3 m in length were counted as root wads; if root wads were attached to stems greater than 3 m in length, they were counted in the large woody debris category. Watershed Consulting used Forest Service R1/R4 methods for counting LWD. This included woody debris pieces at least 3 meters in length or 2/3 bankfull width, and 4 inches in diameter, and within the active channel or influenced by bank full flows.

Results: Other Data

Table F-7. LWD Summary for Mainstem Prospect Creek, WWP Reaches 1-7

Parameter	Average*	Other LCFR Tributaries	Relative to Other LCFR Tributaries
Large woody debris (pieces/mile)	55	182	-127
Small woody debris (pieces/mile)	36	158	-122
Woody Debris Aggregations (pieces/mile)	9	23	-13
Rootwads (pieces/mile)	0.8	47	-39
*Values are averages of WWP Reaches 1 -7.			

Reference: WWP, 1996

Table F-8. LWD Frequency in the Prospect Creek Watershed

Water Body	Reach	Rosgen Stream Type	LWD >3.0 m (singles + aggs + RW) (pieces/mile) WWP, 1996	LWD > 3.0 m (singles + aggs) (pieces/mile) Watershed Consulting, 1999
Main Stem	2	D4/C4	153*	64
Main Stem	3	D4/C4	153*	46
Main Stem	4	D4/3	153*	60
Main Stem	5 (FS R3)	C	153*	57
Crow Creek	1	C3/4	250	--
Crow Creek	2	C3/4	250	--
*Value is for WWP Reach 4 which is approximately equal to RDG Reaches 2-5.				

Reference: WWP, 1996 and Watershed Consulting, 1999

Percent Surface Fines

Methods: TMDL Data

Evaluation of percent fines in spawning areas (typically pool tailouts) provides an indicator of spawning habitat conditions. A high percentage of inter-gravel fines in spawning areas is detrimental to fry development. Evaluation of percent fines in riffles provides an indicator of

macroinvertebrate life support. A high percentage of inter-gravel fines in riffles may be detrimental to macroinvertebrates.

Particle size distributions and percent surface fines (PSF) were derived from data collected by the RDG and USFS using Wolman Pebble counts at both riffle and pool cross sections (**Table F-9**). Values for 2 mm and 6.35 mm size classes were interpolated from cumulative percent-finer-than plots. The 49-point grid toss method was used by the USFS to estimate PSF in riffles and pool tailouts. (**Table F-9**).

Results: TMDL Data

Table F-9. Percent Surface Fines in Prospect Creek Watershed (2004)*

Water Body	Surveyor	Reach/ Cross Section	Rosgen Stream Type	Feature	Wolman Pebble Count		Median Grid Toss (% < 6.35 mm)
					% Fines < 2 mm	% Fines < 6.4 mm	
Main Stem	RDG	1 / 1	B3c/F3	riffle	10	13	--
Main Stem	RDG	1 / 2	B2-3c/F2-3	step/pool	6	12	--
Main Stem	RDG	1 / 2	B2-3c/F2-3	pool	13	15	--
Main Stem	RDG	2 / 1	D4	riffle	17	20	--
Main Stem	RDG	2 / 1	D4	pool	33	33	--
Main Stem	RDG	2 / 2	D4/C4	pool	31	31	--
Main Stem	RDG	2 / 3	C4	riffle	11	13	--
Main Stem	RDG	‘Ref’ C / 1	Ref C4	riffle	12	12	--
Main Stem	RDG	‘Ref’ C / 1	Ref C4	pool	18	19	--
Main Stem	RDG	‘Ref’ C / 2	Ref C4	riffle	7	8	--
Main Stem	RDG	‘Ref’ C / 2	Ref C4	pool	14	15	--
Main Stem	RDG	3 / 1	C3	riffle	0	1	--
Main Stem	RDG	3 / 2	D4	braid	6	6	--
Main Stem	RDG	3 / 3	D4	braid	7	11	--
Main Stem	RDG	3 / 4	C4	riffle	5	6	--
Main Stem	RDG	4 / 1	D4	braid	10	12	--
Main Stem	RDG	4 / 2	D3	braid	3	3	--
Main Stem	RDG	4 / 3	D4b	riffle	7	8	--
Main Stem	Lolo NF	5 / 1 (FS R4)	C	riffle	13	17	2.0
Main Stem	Lolo NF	5 / 2 (FS R4)	C	riffle	14	18	26.5
Main Stem	Lolo NF	5 / 2 (FS R4)	C	pool	13	18	6.1
Main Stem	Lolo NF	5 (FS R3)	C	riffle	3	5	4.1
Main Stem	Lolo NF	5 (FS R3)	C	pool	6	7	2.0
Main Stem	Lolo NF	6 (FS R1)	B	riffle	14	14	2.0
Main Stem	Lolo NF	6 (FS R1)	B	pool	12	16	4.1
Clear	RDG	1 / 1	C4	riffle	7	8	--
Clear	RDG	1 / 2	C4	riffle	8	10	--
Clear	RDG	1 / 2	C4	pool	15	17	--
Clear	RDG	2	B4c/F4b	step/pool	4	5	--
Clear	RDG	3	C4	riffle	9	12	--
Clear	RDG	3	C4	pool	46	46	--
Clear	RDG	4	D4	braid	30	35	--
Clear	RDG	4	D4	pool	8	8	--
Clear	Lolo NF	6 (FS R2)	C	riffle	5	7	4.1

Table F-9. Percent Surface Fines in Prospect Creek Watershed (2004)*

Water Body	Surveyor	Reach/ Cross Section	Rosgen Stream Type	Feature	Wolman Pebble Count		Median Grid Toss (% < 6.35 mm)
					% Fines < 2 mm	% Fines < 6.4 mm	
Clear	Lolo NF	8 (FS R2b)	C	riffle	17	20	4.1
Clear	Lolo NF	8 (FS R2b)	C	pool	21	23	0.0
Clear	Lolo NF	9	A/B	--	--	--	--
Clear	DEQ	C13CLER01			15	17	
Clear	DEQ	C13CLER02			39	40	
Dry	RDG	1	C4	riffle	16	20	--
Dry	RDG	2	A3	riffle	5	6	--
Dry	RDG	2 / 1	A3	pool	14	19	--
Dry	RDG	3	C4	riffle	17	17	--
Dry	RDG	3 / 1	C4	pool	28	28	--
Dry	RDG	4WF	D4b	braid	19	22	--
Dry	RDG	4WF	D4b	pool	23	37	--
Dry	RDG	4EF	D4b	braid	20	35	--
Dry	RDG	4EF	D4b	pool	49	58	--
Dry	RDG	5WF	Ref B4	riffle	16	18	--
Dry	RDG	5WF	Ref B4	pool	28	28	--
Dry	Lolo NF	3 (FS R1)	C4	riffle	16	18	12.2
Dry	Lolo NF	3 (FS R1)	C4	pool	38	46	61.2
Dry	Lolo NF	5EF	C4	riffle	31	37	4.1
Dry	Lolo NF	5EF	C4	pool	19	25	18.4
Dry	Lolo NF	5WF	B4	riffle	33	34	2.0
Dry	Lolo NF	5WF	B4	pool	16	19	16.3
Dry	DEQ	C13DRY01			21	23	
Wilkes	RDG	1	B4c	riffle	7	9	--
Wilkes	RDG	1	B4c	pool	19	20	--
Wilkes	RDG	2	C4	riffle	10	13	--
Wilkes	RDG	2	C4	pool	11	15	--
Wilkes	RDG	3	B4c	riffle	15	16	--
Wilkes	RDG	3	B4c	pool	12	24	--
Wilkes	Lolo NF	2 / 1	C4	riffle	19	19	8.2
Wilkes	Lolo NF	2 / 1	C4	pool	14	18	16.3
Wilkes	Lolo NF	2 / 2	C4	riffle	22	23	2.0
Wilkes	Lolo NF	2 / 2	C4	pool	22	27	8.2
Crow	Lolo NF	1		pool	9	13	--
Crow	Lolo NF	2 / 1	C3/4	riffle	11	14	6.1
Crow	Lolo NF	2 / 1	C3/4	pool	--	--	2.0
Crow	Lolo NF	2 / 2	C3/4	riffle	16	20	8.2
Crow	Lolo NF	1EF / 1	C4b	riffle	21	24	4.1
Crow	Lolo NF	1EF	C4b	pool	--	--	42.9
Crow	Lolo NF	1EF / 2	C4b	riffle	27	30	14.3
Crow	Lolo NF	1EF / 2	C4b	pool	61	65	--
Crow	Lolo NF	1WF / 1	C4b	riffle	34	38	6.1
Crow	Lolo NF	1WF / 1	C4b	pool	--	--	6.1
Crow	Lolo NF	1WF / 2	C4b	riffle	23	26	8.2
Crow	Lolo NF	1WF / 2	C4b	pool	13	15	--
Cooper	Lolo NF	1	F3	pool	--	--	32.7

Table F-9. Percent Surface Fines in Prospect Creek Watershed (2004)*

Water Body	Surveyor	Reach/ Cross Section	Rosgen Stream Type	Feature	Wolman Pebble Count		Median Grid Toss (% < 6.35 mm)
					% Fines < 2 mm	% Fines < 6.4 mm	
Cooper	Lolo NF	2 / 1 (FS R1)	B3c	riffle	5	8	4.1
Cooper	Lolo NF	2 / 2 (FS R1)	B3c	riffle	3	4	2.0
Cooper	Lolo NF	2 / 2 (FS R1)	B3c	pool	13	14	--
Cooper	Lolo NF	3 (FS R2)	C4/D4	riffle	13	20	0.0
Cooper	Lolo NF	3 (FS R2)	C4/D4	pool	--	--	14.3
Cooper	Lolo NF	4 (FS R3)	C4/B	riffle	22	26	10.2
Cooper	Lolo NF	4 (FS R3)	C4/B	pool	38	50	--
* Data was not collected for all reaches. Only those sites with PSF samples are listed in this table.							

Channel Morphology and Stability

Three channel assessments have been completed on Prospect Creek since 1992. Washington Water Power (WWP) completed a stream and fish habitat assessment between 1992 and 1994 as part of the *Lower Clark Fork River Tributary Survey* (WWP, 1996). Watershed Consulting, LLC (WC) completed a channel, fish habitat, and fish population assessment in 1999 (Watershed Consulting, 1999). RDG and USFS completed a comprehensive watershed assessment in 2003. The results of the 2003 assessment, which were summarized in RDG, 2004, are presented in the following section.

In 2003, channel morphology was assessed through channel cross sections, substrate particle distribution, departure analysis, and stream bank modifications. Channel morphology and stability is also related to stream temperature and bank erosion. Temperature data and results as related to channel morphology and riparian vegetation are discussed in Appendices F, J, and K. Stream bank erosion inventory and sediment quantification are presented in **Section 5.0.**

Channel Cross-Section Dimensions

Methods

Channel cross-section surveys were completed from the USGS gage station on Prospect Creek (Reach 1) upstream to the confluence of Twentythreemile Creek and Glidden Gulch (Reach 5). Cross-section surveys were also completed on major tributaries including Dry, Clear, Wilkes, Cooper and Crow creeks. The data collection protocol included surveys equivalent to Rosgen Level II existing stream condition and Level III channel departure analysis (Rosgen, 1996). Among the parameters determined from cross-section data were bankfull width, mean depth, and width-to-depth ration (**Table F-10**). For stream classification purposes, water surface slope through the cross section and width of the floodprone area (at 2 times maximum riffle depth for determining entrenchment ratio) were also measured. Sinuosity was determined from air photo interpretation.

Results

Table F-10. Channel Metrics in Prospect Creek Watershed

Water Body	Surveyors	Reach / Cross Section	Rosgen	Width (ft)	Mean Depth (ft)	W/D ratio	Feature	Existing Sinuosity	Entrenchment Ratio	Slope
Main Stem	RDG	1 / 1	B3c/F3	77.6	2.4	31.9	riffle	1.02	1.29	0.76
Main Stem	RDG	1 / 2	B2-3c/ F2-3	51.3	4.5	11.5	step/pool	1.02	--	1.43
Main Stem	RDG	2 / 1	D4	211.4	0.9	225.3	riffle	1.06	1.96	0.62
Main Stem	RDG	2 / 2		102.1			pool	1.04	3.43	0.83
Main Stem	RDG	2 / 3	C4	87.5	2.4	36.2	riffle	1.15	--	0.5
Main Stem	RDG	‘Ref’C/1	C4	114.8	1.1	102.1	riffle	1.7	>2x	0.64
Main Stem	RDG	‘Ref’C/2	C4	68.6	1.0	70.5	riffle	1.7	>2x	0.64
Main Stem	RDG	3 / 1	C3	61.7	2.0	30.4	riffle	1.12	--	0.47
Main Stem	RDG	3 / 2	D4	179.9	0.6	319.1	braid	1.09	1.95	1.63
Main Stem	RDG	3 / 3	D4	104.4	0.5	212.4	braid	1.05	1.77	1.11
Main Stem	RDG	3 / 4	C4	49.6	1.8	27.1	riffle/Ref C	1.46	8.06	0.66
Main Stem	RDG	4 / 1	D4	118.0	1.2	99.4	braid	1.03	2.54	1.42
Main Stem	RDG	4 / 2	D3	81.7	0.8	108.7	braid	1.08	3.18	1.18
Main Stem	RDG	4 / 3	D4b	83.1	0.8	103.8	riffle	1.15	--	2.07
Main Stem	LNF	5 / 1 (FS R4)	C	37.3	1.7	31.7	riffle	1.36	6.74	2.06
Main Stem	LNF	5 / 2 (FS R4)	C	40.9	1.3	31.4	riffle	1.36	2.13	2.06
Main Stem	LNF	5 (FS R3)	C	33.2	2.3	14.6	riffle	1.1	9.04	2.38
Main Stem	LNF	6 (FS R1)	B	32.1	2.3	13.8	riffle	1.04	2.02	2.72
Clear	RDG	1 / 1	C4	29.1	0.4	73.2	riffle	1.14	2.34	0.47
Clear	RDG	1 / 2	C4	34.6	1.0	34.8	riffle	1.14	2.72	0.48
Clear	RDG	2	B4c/F4b	26.5	1.9	13.7	step/pool	1.09	1.40	0.92
Clear	RDG	3	C4	38.8	1.2	32.3	riffle	1.5	1.57	0.62
Clear	RDG	4	D4	353.2	0.8	441.0	braid	1.05	1.06	0.50
Clear	LNF	1	C4/D4	--	--	--	--	1.12	--	--
Clear	LNF	2	C4/D4	--	--	--	--	1.12	--	--
Clear	LNF	3	C4/D4	--	--	--	--	1.24	--	--
Clear	LNF	4	C4/D4	--	--	--	--	1.32	--	--
Clear	LNF	5	F3	--	--	--	--	1.12	--	--
Clear	LNF	6 (FS R2)	C	36.8	1.4	25.8	riffle	1.3	5.43	0.5
Clear	LNF	7 (FS R2b)	B3/C3	20.9	1.5	13.6	Riffle	1.05	7.18	2.96
Clear	LNF	8	C	20.9	1.5	13.6	riffle	*	--	--
Clear	LNF	9	A/B	--	--	--	--	*	--	--
Dry	RDG	1	C4	27.7	1.2	23.6	riffle	1.4	>2x	0.80
Dry	RDG	2	A3	20.0	2.7	7.4	riffle	1.15	1.4	7.65
Dry	RDG	3	C4	27.5	0.7	39.8	riffle	1.7	1.09	1.20
Dry	RDG	4WF	D4b	71.3	0.3	229.7	braid	1.5	2.31	2.40
Dry	RDG	4EF	D4b	67.0	0.63	107.2	braid	1	2.30	2.40

Table F-10. Channel Metrics in Prospect Creek Watershed

Water Body	Surveyors	Reach / Cross Section	Rosgen	Width (ft)	Mean Depth (ft)	W/D ratio	Feature	Existing Sinuosity	Entrenchment Ratio	Slope
Dry	RDG	5WF	Ref B4	14.2	1.2	11.7	riffle	1.03	1.83	2.42
Dry	LNF	3	C4	20.8	1.7	12.6	riffle	1.13	--	--
Dry	LNF	5EF	C4	14.7	1.2	12.7	riffle	1.2	4.42	1.83
Dry	LNF	5WF	B4	13.0	1.9	7.0	riffle	1.02	13.3	3.57
Wilkes	RDG	1	B4c	13.4	1.3	10.5	riffle	1.07	1.72	1.89
Wilkes	RDG	2	C4	14.6	0.9	17.0	riffle	1.5	2.40	1.80
Wilkes	RDG	3	B4c	17.6	1.1	16.5	riffle	1.33	1.19	2.0
Wilkes	LNF	2 / 1	C4	17.8	1.0	17.8	riffle	1.23	2.31	2.1
Wilkes	LNF	2 / 2	C4	19.1	1.6	12.0	riffle	1.23	8.38	2.1
Crow	LNF	2 / 1	C3/4	28.9	1.4	20.5	riffle	1.14	4.6	2.2
Crow	LNF	2 / 2	C3/4	26.2	1.5	17.2	riffle	1.14	7.17	2.2
Crow	LNF	1EF / 1	C4b	19.3	1.2	16.7	riffle	*	3.09	3.82
Crow	LNF	1EF / 2	C4b	19.8	1.3	15.6	riffle	*	4.37	3.82
Crow	LNF	1WF / 1	C4b	17.7	1.5	12.0	riffle	*	9.89	2.24
Crow	LNF	1 / 2	C4b	17.9	1.5	12.2	riffle	*	8.38	2.24
Cooper	LNF	1	F3	--	--	--	--	1	--	--
Cooper	LNF	2 / 1	B3c	27.5	1.7	16.7	riffle	1.31	1.35	1.75
Cooper	LNF	2 / 2	B3c	30.5	1.4	21.3	riffle	1.31	1.87	1.75
Cooper	LNF	3	C4/D4	73.1	0.7	104.9	riffle	1.23	2.74	3.18
Cooper	LNF	4	C4/B	21.7	2.3	9.3	riffle	1.26	8.25	1.11
Cooper	LNF	5	B4/C	--	--	--	--	1.15	--	--
Cooper	LNF	6	C4/B	36.4	--	--	riffle, spot measurements	1.09	--	--
Cooper	LNF	6	C4/B	20.5	--	--	riffle, spot measurements	1.09	--	--
Cooper	LNF	7	B4 to C4	14.8	--	--	riffle, spot measurements	1.22	--	--
Cooper	LNF	8	A	--	--	--	--	1.23	--	--

--No value.
* Sinuosity difficult or impossible to measure due to dense vegeation cover and/or to stream size relative to photo scale.

Riffle Substrate Distribution

Methods

Wolman pebble counts were used by RDG and USFS to determine channel substrate particle size distribution in both riffles and pools. Pebble counts and cross sections are positioned at a location along the reach that is representative of conditions throughout the reach. They represent one sample along the length of a stream reach. A cumulative percent finer-than graph was generated

for each cross-section pebble count. For Wolman pebble counts in riffles, cumulative percent finer-than graphs were used to interpolate percent fines less than 6.35mm and less than 2mm (**Table F-11**).

Evaluation of percent fines in spawning areas (typically pool tailouts) provides an indicator of spawning habitat conditions. A high percentage of inter-gravel fines in spawning areas is detrimental to fry development. Evaluation of percent fines in riffles provides an indicator of macroinvertebrate life support. A high percentage of inter-gravel fines in riffles may be detrimental to macroinvertebrates.

The Riffle Stability Index was also evaluated (Kapperser, 2002). The length of the median axis was recorded for each of the thirty largest mobile particles on the lower 1/3 of a point bar near each riffle cross section, if a point bar could be located. The geometric mean of the thirty largest bar particles was calculated and compared to the d50 from the riffle pebble count distribution. The RSI value is the percent-finer than value from the riffle percent-finer than distirubtuion curve that corresponds to the geometric mean particle size of the bar particles. High RSI values occur when a portion of channel substrate (d50 of the riffle) is smaller than the average bar particle, indicating excess sediment loading. Low RSI values occur when a small portion of the the channel substrate is finer than the average bar particle indicating channel scour. Moderate RSI values occur when a moderate portion of the channel substrate is smaller than the average bar particle indicating dynamic equilibrium (Kappesser, 2002).

Results

Table F-11 Substrate Distribution in Prospect Creek Watershed*

Waterbody	Surveyors	Reach	Rosgen	Feature	d50	% Fines < 2	% Fines < 6.4	Mean Bar (mm)	% Finer Than RSI
Main Stem	RDG	1 / 1	B3c/F3	riffle	56.7	10	13	--	--
Main Stem	RDG	1 / 2	B2-3c / F2-3	step/pool	273.9	6	12	--	--
Main Stem	RDG	1 / 2	B2-3c / F2-3	pool	124.4	13	15	--	--
Main Stem	RDG	2 / 1	D4	riffle	34.4	17	20	105	97
Main Stem	RDG	2 / 1	D4	pool	10.8	33	33	--	--
Main Stem	RDG	2 / 2	D4/C4	pool/ braid	28.5	31	31	118	98
Main Stem	RDG	2 / 3	C4	riffle	44.1	11	13	--	
Main Stem	RDG	‘Ref" C / 1	Ref C4	riffle	41.2	12	12	162	96
Main Stem	RDG	‘Ref" C / 1	Ref C4	pool	29.7	18	19	--	--
Main Stem	RDG	‘Ref" C / 2	Ref C4	riffle	46.2	7	8	171	98
Main Stem	RDG	‘Ref" C / 2	Ref C4	pool	31.0	14	15	--	--
Main Stem	RDG	3 / 1	C3	riffle	66.8	0	1	--	--
Main Stem	RDG	3 / 2	D4	braid	56.3	6	6	211	97
Main Stem	RDG	3 / 3	D4	braid	57.0	7	11	148	90
Main Stem	RDG	3 / 4	C4	riffle	48.0	5	6	--	--
Main Stem	RDG	4 / 1	D4	braid	52.0	10	12	161	85
Main Stem	RDG	4 / 2	D3	braid	97.4	3	3	224	89
Main Stem	RDG	4 / 3	D4b	riffle	128.0	7	8	194	77
Main Stem	LNF	5 / 1 (FS R4)	C	riffle	75.2	13	17	--	--
Main Stem	LNF	5 / 2 (FS R4)	C	riffle	53.9	14	18	--	--
Main Stem	LNF	5 / 2 (FS R4)	C	pool	49.6	13	18	--	--
Main Stem	LNF	5 (FS R3)	C	riffle	103.2	3	5	174	78
Main Stem	LNF	5 (FS R3)	C	pool	96.0	6	7	--	--
Main Stem	LNF	6 (FS R1)	B	riffle	91.3	14	14	--	--
Main Stem	LNF	6 (FS R1)	B	pool	59.1	12	16	--	--

Table F-11 Substrate Distribution in Prospect Creek Watershed*

Waterbody	Surveyors	Reach	Rosgen	Feature	d50	% Fines < 2	% Fines < 6.4	Mean Bar (mm)	% Finer Than RSI
Clear	RDG	1 / 1	C4	riffle	26.6	7	8	--	--
Clear	RDG	1 / 2	C4	riffle	37.3	8	10	--	--
Clear	RDG	1 / 2	C4	pool	41.6	15	17	--	--
Clear	RDG	2	B4c/F4b	step/pool	38.3	4	5	--	--
Clear	RDG	3	C4	riffle	30.3	9	12	78	97
Clear	RDG	3	C4	pool	12.0	46	46	--	--
Clear	RDG	4	D4	braid	14.6	30	35	95	98
Clear	RDG	4	D4	pool	24.0	8	8	--	--
Clear	LNF	6 (FS R2)	C	riffle	83.2	5	7	125	65
Clear	LNF	8 (FS R2b)	C	riffle	59.6	17	20	112	24
Clear	LNF	8 (FS R2b)	C	pool	66.5	21	23	--	--
Clear	DEQ	C13CLER01			37.3	15	17	--	--
Clear	DEQ	C13CLER02			25.1	39	40	--	--
Dry	RDG	1	C4	riffle	38.5	16	20	84	80
Dry	RDG	2	A3	riffle	73.3	5	6	--	--
Dry	RDG	2 / 1	A3	pool	51.6	14	19	--	--
Dry	RDG	3	C4	riffle	35.8	17	17	121	93
Dry	RDG	3 / 1	C4	pool	22.0	28	28	--	--
Dry	RDG	4WF	D4b	braid	38.7	19	22	--	--
Dry	RDG	4WF	D4b	pool	19.6	23	37	--	--
Dry	RDG	4EF	D4b	braid	7.8	20	35	--	--
Dry	RDG	4EF	D4b	pool	2.4	49	58	--	--
Dry	RDG	5WF	Ref B4	riffle	58.7	16	18	--	--
Dry	RDG	5WF	Ref B4	pool	13.9	28	28	--	--
Dry	LNF	3 (FS R1)	C4	riffle	56.7	16	18	70	68
Dry	LNF	3 (FS R1)	C4	pool	56.7	38	46	--	--
Dry	LNF	EF	C4	riffle	56.7	31	37	108	92
Dry	LNF	EF	C4	pool	27.2	19	25	--	--

Table F-11 Substrate Distribution in Prospect Creek Watershed*

Waterbody	Surveyors	Reach	Rosgen	Feature	d50	% Fines < 2	% Fines < 6.4	Mean Bar (mm)	% Finer Than RSI
Dry	LNF	WF	B4	riffle	29.4	33	34	--	--
Dry	LNF	WF	B4	pool	36.3	16	19	--	--
Wilkes	RDG	1	B4c	riffle	58.6	7	9	--	--
Wilkes	RDG	1	B4c	pool	32.0	19	20	--	--
Wilkes	RDG	2	C4	riffle	41.5	10	13	122	81
Wilkes	RDG	2	C4	pool	34.5	11	15	--	--
Wilkes	RDG	3	B4c	riffle	60.7	15	16	--	--
Wilkes	RDG	3	B4c	pool	49.4	12	24	--	--
Wilkes	LNF	2 / 1	C4	riffle	43	19	19	--	--
Wilkes	LNF	2 / 1	C4	pool	45.9	14	18	--	--
Wilkes	LNF	2 / 2	C4	riffle	44.6	22	23	105	77
Wilkes	LNF	2 / 2	C4	pool	19.8	22	27	--	--
Crow	LNF	1		pool	48.6	9	13	--	--
Crow	LNF	2 / 1	C3/4	riffle	57.0	11	14	--	--
Crow	LNF	2 / 2	C3/4	riffle	49.0	16	20	--	--
Crow	LNF	1EF / 1	C4b	riffle	43.7	21	24	--	--
Crow	LNF	1EF / 2	C4b	riffle	27.7	27	30	--	--
Crow	LNF	1EF / 2	C4b	pool	0.4	61	65	--	--
Crow	LNF	1WF / 1	C4b	riffle	18.3	34	38	112	71
Crow	LNF	1WF / 2	C4b	riffle	51.6	23	26	--	--
Crow	LNF	1WF / 2	C4b	pool	36.6	13	15	--	--
Cooper	LNF	2 / 1 (FS R1)	B3c	riffle	96	5	8	--	--
Cooper	LNF	2 / 2 (FS R1)	B3c	riffle	106.3	3	4	--	--
Cooper	LNF	2 / 2 (FS R1)	B3c	pool	54.44	13	14	--	--
Cooper	LNF	3 (FS R2)	C4/D4	riffle	28.29	13	20	119	98
Cooper	LNF	4 (FS R3)	C4/B	riffle	36.45	22	26	116	77
Cooper	LNF	4 (FS R3)	C4/B	pool	6	38	50	--	--

* Data was not collected for all sample reaches. Only those sites with LWD samples are listed in this

Table F-11 Substrate Distribution in Prospect Creek Watershed*

Waterbody	Surveyors	Reach	Rosgen	Feature	d50	% Fines < 2	% Fines < 6.4	Mean Bar (mm)	% Finer Than RSI
table.									

Channel Departure Analysis

Methods

RDG evaluated 1947 and 2000 aerial photos to measure meander geometry dimensions and identify factors influencing channel form and function. Meander geometry dimensions including bankfull width, sinuosity, meander length, meander belt width, and radius of curvature were measured to evaluate stream type changes resulting from direct and indirect channel modifications as well as riparian vegetation changes. Channel length reductions associated with highway construction and with channel adjustments were also measured.

Results

Table F-12 summarizes bankfull width, meander length, sinuosity, meander belt width, and radius of curvature measured from the 1947 and 2000 photos. A more detailed presentation of data results for Reaches 3 and 4 can be found in Tables 3-15 and 3-19 respectively in the Phase I TMDL document (RDG, 2004). **Table F-13** summarizes results of channel length analysis for mainstem Prospect Creek from 1947 to 2000.

Table F-12. Summary of Plan Form Geometry for Mainstem Prospect Creek, Reaches 1 through 5, from 1947 to 2000

Reach	Dominant Channel Type	Bankfull channel width (ft)		Meander Length (ft)		Sinuosity		Meander Belt Width (ft)		Radius of Curvature (ft)	
		1947	2000	1947	2000	1947	2000	1947	2000	1947	2000
1	B	*	65	*	802	1.11	1.11	*	208	*	413
2	C-D	141	163	610	893	1.15	1.06	279	401	214	275
3	C-D	126	148	714	1149	1.25	1.14	250	423	273	400
4	C-D	60	68	843	887	1.16	1.08	304	307	289	336
5	B	*	24	583	508	1.17	1.11	233	122	164	199
* Sufficient aerial photos not available.											

Table F-13. Channel Length Analysis Results for Mainstem Prospect Creek from Evans Gulch Downstream to Clear Creek

Photo Series	Channel Length [feet (miles)]	Cause and Channel Length Reduction		
		Highway Construction	Channel Adjustments	
1947	110,074 (20.8)	2,748 ft	5,242 ft	
2000	102,084 (19.3)			

Streambank Modifications

Methods

During 2003, the length of Prospect Creek mainstem was inventoried for streambank modifications. Location, length, and type were noted for each streambank modification observed. Types of modifications observed include rip rap, rootwads and other native material revetments, channel structures and combinations thereof.

Streambank modifications were also catalogued by the Green Mountain Conservation District based on 310 permit applications. A comprehensive list of approved applications to date is provided in **Table F-14** including permit number, applicant, and description of activity. (GMCD, 2005)

Table F-14. 310 Permits Issued by Green Mountain Conservation District for Streambank Modification/Alteration

Permit #	Applicant	Description
SW-03-76	YPL	Recover pipe
SW-07-81	YPL	Install gabions & riprap
SW-09-81	Silver Star Mines	Bulldozen channel away from power line
SW-02-82	Wilkinson	Diversion for Hydro-electric plant
SW-06-82	YPL	Lower exposed pipeline
SW-02-83	YPL	Lower pipeline
SW-06-87	Hagaman Logging	Stream bed crossing
SW-22-88	Dwyer	Timber removal and bridge construction
SW-02-89	Dwyer	Timber thinning; bridge construction
SW-10-90	Baxter	Bank stabilization with riprap
SW-12-90	Kirk Bay	Logging truck crossing
SW-16-90	YPL	Pipeline maintenance
SW-19-90	Dwyer	Construction clean-up
SW-32-93	J&N Harvesting	Set railroad car
SW-36-93	Dwyer	Temporary bridge
SW-37-93	Kraak	Hillside logging
SW-39-93	Hensyel	Haul logs across streambed
SW-01V-94	Dwyer	Tree removal
SW-22-94	Birchard	Power generating structure
SW-47-94	Reed	Haul logs across streambed
SW-02-95	Ahlf	Bridge replacement
SW-03E-95	YPL	Emergency bank stabilization
SW-03-96	YPL	Bank stabilization
SW-04-96	YPL	Bank stabilization
SW-05-96	YPL	Bank stabilization
SW-06-96	Anderson	Bank stabilization
SW-07-96	MT Power	Bank stabilization
SW-23E-96	YPL	Emergency sand bagging
SW-25-96	YPL	Bank stabilization
SW-26-96	YPL	Bank stabilization
SW-27-96	YPL	Bank stabilization
SW-28-96	YPL	Bank stabilization
SW-29-96	YPL	Bank stabilization
SW-30-96	YPL	Bank stabilization
SW-43-96	YPL	MP 435.5 maintenance
SW-44-96	YPL	MP 428.7 & 428.8 maintenance
SW-50-96	YPL	MP 421.5 maintenance
SW-07-97	YPL	MP 424.6 maintenance
SW-08-97	YPL	MP 424.9 maintenance
SW-10E-97	YPL	MP 420.4 maintenance
SW-11E-97	YPL	MP 421.3 maintenance
SW-50-97	YPL	MP 420.3 maintenance
SW-51-97	YPL	MP 420.9 maintenance

Table F-14. 310 Permits Issued by Green Mountain Conservation District for Streambank Modification/Alteration

Permit #	Applicant	Description
SW-52-97	YPL	MP 423.7 maintenance
SW-53-97	YPL	MP 423.8 maintenance
SW-54-97	YPL	MP 428.7 maintenance
SW-55-97	YPL	MP 434.7 maintenance
SW-56-97	YPL	MP 434.8 maintenance
SW-67-97	MT Power	Remover power pole
SW-05-98	Merritt	Pond
SW-11E-98	MT Power	Emergency tree removal
SW-13-98	MT Power	Power lines
SW-31-98	YPL	Pipe stabilization
SW-32-98	YPL	Bank stabilization
SW-33-98	YPL	MP 429.4 maintenance
SW-34-98	YPL	MP 429.5 maintenance
SW-35-98	YPL	MP 432.7 maintenance
SW-36-98	YPL	MP 432.9 maintenance
SW-07A-99	PCWC	(Phase 1) Bank stabilization and alteration
SW-07B-99	PCWC	(Phase 1) Bank stabilization and alteration
SW-07C-99	PCWC	(Phase 1) Bank stabilization and alteration
SW-07D-99	PCWC	(Phase 1) Bank stabilization and alteration
SW-07E-99	PCWC	(Phase 1) Bank stabilization and alteration
SW-12A-99	PCWC	(Phase 2) Bank stabilization and alteration
SW-12B-99	PCWC	(Phase 2) Bank stabilization and alteration
SW-12C-99	PCWC	(Phase 2) Bank stabilization and alteration
SW-12D-99	PCWC	(Phase 2) Bank stabilization and alteration
SW-12E-99	PCWC	(Phase 2) Bank stabilization and alteration
SW-04-00	Touch America	Fiber Optic Utilities
SW-08A-00	PCWC	Bank stabilization; channel alteration
SW-08B-00	PCWC	Bank stabilization; channel alteration
SW-08C-00	PCWC	Bank stabilization; channel alteration
SW-08D-00	PCWC	Bank stabilization; channel alteration
SW-27V-00	Unknown	
SW-40-00	MPC	Temporary stream crossing
SW-42-00	Flamming	Bank stabilization; channel alteration
SW-45-00	Cheetham	Bank stabilization
SW-01-01	YPL	Misc. stream work
SW-02-01	Reed/Reeser	Temporary stream crossing
SW-32-01	Dwyer	Temporary stream crossing
SW-27-02	YPL	Pipeline re-route
SW-32-02	Cheetham	Irrigation structure
SW-38-02	NW Energy	Power poles
SW-16-04	YPL	Channel alteration
SW-16C-05	Olney	Unpermitted posts
SW-03V-06	Olney	Fence posts
SW-27-06	Stuckey	Irrigation structure
SW-32-06	Olney	Boundry posts
SW-43C-06	Olney	Irrigation structure
Last two digits in permit number denote year of issuance		

The methods and results of assessing sediment sources in the Prospect Creek watershed is discussed in detail in **Section 5.0**. One portion of the sediment source assessment includes an inventory of stream bank erosion and related land uses possibly influencing bank erosion.

Results

Approximately 6,655 linear feet of rip-rap, 2,100 linear feet of rip-rap with rootwads, and 1,800 linear feet of native material bank stabilization techniques have been installed in Reaches 1-4 on the mainstem Prospect (**Table F-15**). An additional 19 rock channel structures have been installed to reduce bank erosion and protect pipeline infrastructure from channel bed scour. Numerous gabion baskets have also been installed. **Table F-15** summarizes the type and total length of inventoried bank stabilization treatments on Prospect Creek. Gabion retaining walls in Reach 5 were not recorded in detail and have been omitted from the summary table.

Table F-15. Type and Total Length of Inventoried Bank Stabilization Treatments on Prospect Creek by Stream Reach (in feet)

Type	Reach 1	Reach 2	Reach 3	Reach 4
Rip-rap	0	3825	2230	600
Rip-rap with rootwads	0	1100	1000	0
Native material*	0	1450	350	0
Channel structures†	0	11	8	0

* Includes tree and rootwad revetment structures coupled with site revegetation
† Includes number of individual rock vane and barb structures

Riparian Vegetation Assessment

Methods

Canopy density analysis for the mainstem Prospect Creek was completed using the 1996 aerial photo series at a scale of 1 inch equals 300 feet. The analysis included reaches 2 through 5 and did not include Reach 1, a higher gradient B channel. Reach 1 is characterized by a confined channel in a steep canyon that terminates at the confluence with the Clark Fork River. It is unlikely that temperature or shading issues are present in this initial reach, although future temperature monitoring is recommended. Sampling locations were established in each stream reach, at equal intervals, enabling a minimum of 30 measurements. A map wheel determined exact sampling locations along the mainstem where a planimeter-type grid, one inch square, with 41 holes was overlain on selected sites. This grid was orientated perpendicular to valley aspect, and encompassed the adjacent floodplain and bankfull channel with plot size determined by local meander belt width. When increased belt widths occurred, the grid size was enlarged to meet the additional area. The grid size was narrowed when the belt width decreased.

Within each selected site, the percent of forested (mature forest and thick willow/alder) land was derived by tallying the number of dots overlying forested areas and dividing by the total number of dots within the plot. Each site was mapped and numbered on the relevant aerial photo.

On August 30, 2005, Montana DEQ collected field measurements of riparian canopy density at some of the aerial photo sample sites using the EMAP method (Lazorchak et. al., 1998). A

densitometer was used to measure canopy shading the stream at three cross-sections within the aerial photo sample site. Cross sections were located in the middle of aerial photo sample site, at an upstream location within the site each site, and at a downstream location with the site. For each cross-section, a densitometer reading was taken at the left bank, the right bank, and in the middle of the channel. All readings were taken with the densitometer at 1 foot above the water surface,

All values were averaged to determine canopy density for the aerial photo site according to a conversation with Heidi Lindgren in 2005.

Table F-16 presents the results of the canopy density aerial photo analysis on the mainstem of Prospect Creek. **Table F-17** includes the results of the DEQ field analysis and comparison with the aerial assessment.

Results

Table F-16. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
2	1	2	150	pvt	NWE	highway		shrub/ small trees	pvt				shrub/ small trees	46
2	2	2	220	pvt	NWE	road	highway	mature trees	pvt	NWE	Restoration attempt		shrub/ small trees	47
2	3	1	100	pvt	highway			shrub/ small trees	pvt				shrub/ small trees	39
2	4	1	120	pvt	highway			bare ground/ grass/ shrub	pvt	road			bare ground/ grass	27
2	5	1	210	pvt	highway			bare ground/ grass/ shrub	pvt	BPA			shrub/ small trees	30
2	6	2	150	pvt	BPA	highway		mature trees	pvt	BPA			shrub/ small trees	68
2	7	1	130	USFS	highway			shrub/ small trees	fs	YPL (original)	NWE	road	shrub/ small trees	74
2	8	2	150	fs	highway			shrub/ small trees	fs				shrub/ small trees	74
2	9	1	90	fs	highway			bare ground/ grass	fs				mature trees	71
2	10	3	300	pvt	highway			shrub/ small trees	pvt	YPL (original)	NWE		shrub/ small trees	41
2	11	1	150	pvt	highway			shrub/ small trees	pvt	YPL (original)			shrub/ small trees	52
2	12	1	150	pvt	highway			bare ground/ grass	pvt	YPL (original)			shrub/ small trees	58

Table F-16. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	**Site**	**# of Threads**	**Total Active Channel Width (feet)**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Percent Canopy**
2	13	2	180	pvt	highway			bare ground/ grass	pvt	YPL (original)			shrub/ small trees	64
2	14	3	210	pvt	highway			shrub/ small trees	pvt	YPL (original)			grass/ shrub	44
2	15	1	165	pvt	highway			grass/ shrub/ small trees	pvt	YPL (original)			shrub/ small trees	39
2	16	1	100	pvt	highway			bare ground/ grass	pvt	YPL (original)	NWE		shrub/ small trees	68
2	17	3	300	pvt	NWE	highway		bare ground/ grass/ shrub	pvt	YPL (original)	NWE		shrub/ small trees	61
2	18	1	135	pvt	YPL (original)			mature trees	pvt				mature trees	77
2	19	1	150	pvt	road			mature trees	pvt	road			shrub/ small trees	74
2	20	1	150	pvt	road			shrub/ small trees	pvt	road			mature trees	68
2	21	2	150	pvt				shrub/ small trees	pvt	road			shrub/ small trees	81
2	22	2	170	pvt	residence			shrub/ small trees	pvt	residence	riparian development		bare ground/ grass	52
2	23	3	120	pvt				shrub/ small trees	pvt				mature trees	64
2	24	4	350	pvt	riparian development	road	residence	bare ground/ grass/ shrub	pvt				mature trees	55
2	25	2	225	pvt				shrub	pvt				shrub/	63

Table F-16. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
													small trees	
2	26	2	350	pvt	residence	highway	NWE	shrub	pvt				shrub/ small trees	49
2	27	1	120	pvt	highway	NWE		shrub/ small trees	pvt				mature trees	49
2	28	1	210	pvt	highway	NWE		bare ground/ grass/ shrub	pvt				mature trees	37
2	29	3	200	pvt	highway	NWE		shrub	pvt				shrub/ small trees	51
2	30	2	375	pvt	residence	riparian development		shrub/ small trees	pvt				shrub/ small trees	60
2	31	1	225	pvt				small trees	pvt				shrub/ mature trees	68
3	1	1	120	pvt				shrub/ small trees	pvt				mature trees	77
3	2	2	300	pvt	residence	riparian development		grass/ shrub/ small trees	pvt				shrub/ small trees	49
3	3	1	150	fs/ pvt				shrub/ small trees	fs/ pvt				mature trees	72
3	4	1	120	fs	YPL (original)	highway	YPL (re-route)	bare ground/ grass/ shrub	fs	YPL (original)			shrub/ small trees	54
3	5	1	180	fs	YPL (original)			grass/ shrub/ small trees	fs	YPL (original)			shrub/ small trees	61
3	6	3	90	pvt				shrub/ small trees	pvt				shrub/ small trees	68
3	7	1	100	fs	pasture			grass/ shrub/	fs				mature	21

Table F-16. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	**Site**	**# of Threads**	**Total Active Channel Width (feet)**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Percent Canopy**
								small trees					trees	
3	8	2	300	pvt	YPL (original)	NWE	riparian development	grass/ shrub/ small trees	pvt				shrub/ small trees	59
3	9	2	160	fs	YPL (original)	NWE		shrub/ small trees	fs				mature trees	54
3	10	1	225	pvt	highway	YPL (re-route)		bare ground/ grass	fs	NWE	YPL (original)		bare ground/ grass/ shrub/ mature trees	56
3	11	2	120	fs	YPL (original)	NWE		shrub/ small trees	fs				shrub/ small trees	76
3	12	2	190	pvt				shrub/ small trees	pvt				mature trees	72
3	13	2	375	pvt	residence	NWE	YPL (re-route)	bare ground/ grass/ shrub	pvt				shrub/ small trees	35
3	14	1	95	pvt				shrub/ small trees	pvt				mature trees	75
3	15	2	135	pvt				geadss/ shrub/ small trees	pvt				mature trees	66
3	16	3	110	pvt				shrub/ small trees	pvt				mature trees	71
3	17	2	120	fs	pasture			bare ground/ grass/ shrub	fs				mature trees	43
3	18	2	150	fs				mature trees	fs				shrub/	74

Table F-16. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
													mature trees	
3	19	1	225	fs	NWE	highway	YPL (re-route)	grass/ mature trees	fs	NWE	YPL (original)		grass/ shrub/ small trees	58
3	20	2	225	fs	highway	YPL (re-route)		bare ground/ grass/ shrub	fs	NWE			bare/ shrub/ small trees	64
3	21	1	100	fs	NWE	YPL (original)	road	bare ground/ grass	fs	road			mature trees	39
3	22	1	200	fs	YPL (original)			bare ground/ grass/ shrub	fs	NWE			shrub/ small trees	38
3	23	1	120	pvt	road	residence	riparian development	grass/ shrub/ small trees	pvt				small/ mature trees	31
3	24	1	95	fs	highway	YPL (re-route)		bare ground/ grass	fs	NWE			shrub/ small trees	45
3	25	1	210	fs	NWE	YPL (original)		shrub/ small trees	fs	NWE	YPL (original)		shrub/ small trees	58
3	26	2	190	fs	NWE	YPL (re-route)	highway/ BPA	shrub/ small trees	fs	NWE			grass/ shrub/ small trees	56
3	27	1	150	fs	YPL (original)			shrub/ small trees	fs				shrub/ small trees	65
3	28	1	120	fs				bare ground/ grass/ shrub	fs	YPL (original)	YPL (original)		grass/ shrub/ small trees	64
3	29	1	100	fs				bare ground/	fs	YPL			grass/	44

Table F-16. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
								grass/ shrub		(original)			shrub/ small trees	
3	30	2	75	fs				shrub/ small trees	fs				shrub/ mature trees	71
3	31	3	65	fs				bare ground/ grass/ shrub	fs				shrub/ small trees	42
3	32	1	150	fs	fire			grass/ shrub/ small trees	fs	fire			shrub/ small trees	47
4	1	2	250	fs				bare ground/ grass	fs				mature trees	25
4	2	3	180	fs				bare ground/ grass/ shrub	fs				grass/ mature trees	32
4	3	3	250	fs				shrub/ small trees	fs	YPL (original)			grass/ shrub/ small trees	34
4	4	1	180	fs				shrub/ mature trees	fs	YPL (original)			shrub/ shrub/ small trees	46
4	5	2	195	fs				shrub/ small trees	fs	YPL (original)			grass/ shrub	26
4	6	3	225	fs				grass/ shrub/ small trees	fs	YPL (original)			grass/ shrub/ small trees	18

Table F-16. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
4	7	3	300	fs					fs	YPL (original)	road	riparian development	bare/ grass/ shrub	17
4	8	2	300	fs				bare ground/ grass/ shrub	fs	road	YPL (original)	NEW	bare/ grass/ shrub	14
4	9	2	300	fs				mature trees	fs	road	NWE	YPL (original)	grass/ shrub/ small trees	25
4	10	2	270	fs				shrub/ mature trees	fs	road	NWE	YPL (original)	grass/ shrub	31
4	11	2	200	fs				mature trees	fs	road	NWE	YPL (original and re-route)	grass/ shrub	25
4	12	1	225	fs	riparian development			grass/ shrub/ small trees	fs	riparian development	NWE	YPL (original and re-route)	bare/ grass/ shrub	28
4	13	1	120	fs				shrub/ small trees	fs				shrub/ small trees	46
4	14	2	70	fs	road			bare ground/ grass/ shrub	fs	road			shrub/ mature trees	44
4	15	1	90	fs				grass/ shrub/ small trees	fs				grass/ shrub/ small trees	39
4	16	1	105	fs				mature trees	fs				shrub/ small trees	41
4	17	1	120	fs				mature trees	fs				mature trees	54
4	18	2	135	fs				mature trees	fs				mature	39

Table F-16. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
													trees	
4	19	2	115	fs				mature trees	fs				mature trees	52
4	20	1	115	fs				mature trees	fs				mature trees	61
4	21	1	135	fs				mature trees	fs	YPL (original)	road	highway	shrub/ small trees	34
4	22	1	90	fs				mature trees	fs	YPL (original)	road		grass/ mature trees	61
4	23	2	75	fs				mature trees	fs				mature trees	90
4	24	1	65	fs				mature trees	fs				mature trees	90
4	25	1	75	fs				mature trees	fs				mature trees	71
4	26	2	90	fs				mature trees	fs				grass/ mature trees	63
4	27	2	110	pvt	riparian clearing	road		bare ground/ grass/ shrub	pvt	riparian development			grass/ shrub/ small trees	32
4	28	2	105	fs				mature trees	fs				mature trees	76
4	29	2	150	fs				shrub/ small trees	fs	YPL (original)			mature trees	49

Table F-16. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	**Site**	**# of Threads**	**Total Active Channel Width (feet)**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Land Owner**	**Land Use 1**	**Land Use 2**	**Land Use 3**	**Vegetation**	**Percent Canopy**
4	30	2	190	fs				shrub/ small trees	fs	YPL (original)			shrub/ small trees	40
5	1	1	40	pvt	YPL (original)			mature trees	pvt	riparian development	road	YPL (original)	mature trees	59
5	2	2	80	fs/ pvt	riparian clearing	road		grass/ shrub	fs/ pvt	YPL (original)			shrub/ mature trees	53
5	3	1	60	fs				mature trees	fs	YPL (original)	YPL (re-route)		mature trees	56
5	4	1	50	fs				mature trees	fs				shrub/ mature trees	53
5	5	1	75	fs				mature trees	fs				shrub/ small trees	50
5	6	2	50	fs				mature trees	fs				mature trees	57
5	7	1	40	fs				bare ground/ grass/ mature trees	fs				mature trees	43
5	8	2	40	fs				mature trees	fs				shrub/ small trees	50
5	9	1	45	fs				mature trees	fs				mature trees	61
5	10	2	90	fs				mature trees	fs	YPL (original)	highway	YPL (re-route)	grass/ shrubs/ mature	56

Table F-16. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
													trees	
5	11	1	75	fs				shrub/ small trees	fs	YPL (original)	highway	YPL (re-route)	grass/ shrub/ small trees	16
5	12	1	75	fs				shrub/ small trees	fs	YPL (original)			shrub/ small trees	31
5	13	2	100	fs	YPL (original)			shrub/ small trees	fs	YPL (original)	highway		shrub/ small trees	53
5	14	1	90	fs				mature trees	fs	YPL (original)	highway	YPL (re-route)	grass/ shrub/ small trees	53
5	15	1	90	fs	YPL (original)	highway	YPL (re-route)	bare ground/ grass/ shrub	fs	YPL (original)	YPL (re-route)	highway	shrub/ small trees	30
5	16	1	30	fs	YPL (original)			grass/ small trees	fs				mature trees	57
5	17	1	30	fs				mature trees	fs				mature trees	87
5	18	1	20	fs				mature trees	fs				mature trees	87
5	19	1	25	fs				shrub/ mature trees	fs				mature trees	74
5	20	1	45	fs	YPL (original)	highway	YPL (re-route)	grass/ mature trees	fs				mature trees	78
5	21	1	20	fs	YPL (original)	highway	YPL (re-route)	bare ground/ grass	fs				mature trees	50

Table F-16. Land Ownership, Land Uses, and Vegetation Class Associated with Percent Canopy Derived from 1996 Aerial Photo Interpretation Reported in RDG 2004

				Left Bank					Right Bank					
Reach	Site	# of Threads	Total Active Channel Width (feet)	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Land Owner	Land Use 1	Land Use 2	Land Use 3	Vegetation	Percent Canopy
5	22	1	20	fs	YPL (original)	highway	YPL (re-route)	grass/ shrub/ small trees	fs				mature trees	50
5	23	1	20	fs	YPL (original)	highway	YPL (re-route)	grass/ shrub/ small trees	fs				mature trees	64
5	24	1	55	fs	highway	YPL (re-route)		bare ground/ grass	fs	YPL (original)			shrub/ small trees	43
5	25	1	30	fs	highway	YPL (re-route)		bare ground/ grass/ shrub	fs	YPL (original)			shrub/ mature trees	50
5	26	1	30	fs	highway	YPL (re-route)		bare ground/ grass/ shrub	fs	YPL (original)			shrub/ small trees	50
5	27	2	45	fs	YPL (original)			shrub/ small trees	fs	YPL (original)			mature trees	43
5	28	1	25	fs	YPL (original)	highway	YPL (re-route)	grass/ shrub/ small trees	fs				mature trees	57
5	29	1	20	fs	highway	YPL (original)		grass/ mature trees	fs				mature trees	71
5	30	1	25	fs				shrub/ small trees	fs				mature trees	64
5	31	1	20	fs				mature trees	fs				mature trees	71

Table F-17. Comparison of DEQ field data and aerial photo canopy density analysis on mainstem of Prospect Creek

Reach-Site	Field Canopy Cover (%)	Aerial Photo Canopy Cover (%)	Field # of Threads	Aerial Photo # of Threads	Field LB Vegetation	Field RB Vegetation	Aerial Photo LB Vegetation	Aerial Photo RB Vegetation	Total Active Channel Width*
2-4	8	27	1	1	small trees/ brush/grass on gravel bars	small trees/ brush/grass on gravel bars	bare ground/ grass	bare ground/ grass	120
2-8	12	74	Middle xsection:2 Up and Down xsections:1	2	brush/small tree	brush/small tree	shrub/ small trees	shrub/ small trees	150
2-11	19†	52	Upper and Middle xsections:2 Down stream xsection:1	1	road/brush/ grass	small trees/brush	shrub/ small trees	shrub/ small trees	150
2-29	28§	51	1	3	bare/grass	mature tree	shrub/ mall trees	shrub/ small trees	200
3-10	13	56	1	1	rx/grass/ small trees	rx/grass	bare ground/ grass	bare ground/ grass	225
3-11	41	76	1	2	grass/shrub/ small trees	trees	shrub/ small trees	shrub/ small trees	120
3-25	8∞	58	1 active	1	grass/shrub/ small trees	grass/shrub/ small trees	shrub/ small trees	shrub/ small trees	210
3-26	34	56	1	2	grass/shrub/ small trees	mature tree	shrub/ small trees	shrub/ small trees	190
4-21	34	34	DRY - readings are for potential canopy cover	1	mature tree	small trees	mature trees	shrub/ small trees	135
5-11	54	16	1	1	grass/shrub	trees	Shrub/ small trees	shrub/ small trees	75
5-13	44	53	1 (side channel was dry)	2	shrub	shrub	Shrub /small trees	shrub/ small trees	100
5-17	76	87	1	1	mature forest	mature forest	mature trees	mature trees	30
5-29	81	71	1	1	mature forest	mature forest	mature trees	mature trees	20

* Values from Aerial Photo Analysis
† 2-11: Large variability from 1996 photo
§ 2-29: Check aerial photo analysis?
∞ 3-25: Power line disturbance

References

Montana Department of Environmental Quality. 2006. Total Maximum Daily Loads for Metals in Prospect Creek Watershed. Helena, MT: Montana Department of Environmental Quality.

Lazorchak, James M.; D. J. Klemm, D. V. Peck. 1998. Environmental Monitoring and Assessment Program - Surface Waters: Field Operations and Methods for Measuring the Ecological Condition of Wadeable Streams. Washington, D.C.: United States Environmental Protection Agency.

Green Mountain Conservation District. 2005. Approved 310 permits

Kappesser, Gary.B. 2002. A Riffle Stability Index to Evaluate Sediment Loading to Streams. *Journal of the American Water Resources Association* 38-4: 1069-1081.

River Design Group. 2004. Final Prospect Creek Watershed Assessment and Water Quality Restoration Plan. Whitefish, Montana: River Design Group.

Rosgen, Dave L. 1996. Applied River Morphology. Lakewood, CO: Wildland Hydrology.

U.S. Forest Service. 2000. Section 7 Consultation Watershed Baseline:Lower Clark Fork River, Montana. Libby, MT: U.S. Forest Service, Kootenai National Forest.

Washington Water and Power. 1996. Lower Clark Fork River Tributary Survey: Final Report for a Cooperative Challenge Cost Share Project: Volume I of II. Spokane, WA: Washington Water and Power.

Watershed Consulting. 1999. A Geomorphic and Fisheries Habitat Evaluation of Prospect Creek, Montana. Whitefish, MT: Watershed Consulting.

APPENDIX G
REFERENCE VALUE DEVELOPMENT & TARGET JUSTIFICATION

Reference condition values for various water quality parameters were identified using the guidance presented in **Section 3.0**. In general, reference conditions represent either, conditions that have not been noticeably affected by anthropogenic activities (in other words, natural conditions), or conditions that represent the best water quality/land conditions achievable through the proper implementation of all best management practices if a return to natural condition is unachievable or unreasonable.

Given the potential widespread historical human impacts throughout the Prospect Creek Watershed, the use of internal reference values from within the watershed for reference development cannot be justified for many parameters, and historical data is not available for many parameters. This leaves the use of regional reference data as a remaining primary approach used in many of the following sections. Focus is on the use of regional reference data supplemented by some internal Prospect Creek Watershed data and secondary reference development approaches.

Reference values were identified for the following parameters to help determine impairment for cold water-fish and/or aquatic life:

- Percent Surface Fines in Riffles < 6.35 mm (pebble count)
- Percent Surface Fines < 6.35 mm in Pool Tails and Riffles (grid toss or equivalent)
- Percent Substrate Fines in Pool Tails < 6.35 mm (McNeil cores)
- Pool Frequency (number of pools per unit length)
- Width-to-Depth Ratio (ratio of bankfull width to bankfull depth at riffle cross sections)
- Sinuosity
- Riffle Stability Index
- Large Woody Debris (amount of large woody debris per unit length)
- Riparian Vegetation
- Macroinvertebrate Populations

The above parameters cover a broad range of direct habitat measures and measures of channel conditions, as well as a direct measure of aquatic life (macroinvertebrate metrics). All of the above parameters are measures of sediment-related impairments. Parameters associated with temperature-related impairments include width-to-depth ratio, riparian vegetation, macroinvertebrates and fish.

Percent Surface Fines < 6.35 mm in Riffles (pebble counts)

Reference development considered ongoing reference development work in the Yaak Watershed, macroinvertebrate research, and existing watershed conditions.

Reference development work in the Yaak (EPA and KNF unpublished data) has resulted in < 6.35 mm pebble count percent fines reference data mean values ranging from 10 to 13% for B3, B4, C3 and C4 stream types.

Research by macroinvertebrate specialists (Relya, et al., 2004) indicates that when percent surface fines < 2 mm are between 20 to 40%, based on pebble count data, there is a decrease in macroinvertebrate richness.

For all Prospect Creek sites, mean percent surface fines in riffles based on pebble counts is 16%. The standard deviation for these data is 10%, the 75th percentile is 22%, and the median is 18%. These are not true reference values since Prospect Creek is not in reference conditions, but they do represent values that can be attained and may be tracked to indicate potential increased fine sediment inputs.

Collectively, these data suggest that the percent fines < 6.35 mm target should remain below 15%.

Percent Surface Fines < 6.35 mm in Pool Tails and Riffles (grid toss)

Reference development for percent surface fines using the grid-toss method is based on results from several studies (**Table G-1**).

Percent surface fines impairment threshold for the Blackfoot Headwaters TMDL was set at about 6 percent to 8 percent, representing the 75th percentile of the least impacted reaches suitable for developing reference values. The data was collected from numerous pool tails along two 2200' least impacted reaches. This data was collected using a variation of the grid toss approach referred to as a "viewing bucket" approach.

Average grid toss reference condition values measured in undeveloped watersheds on the Lolo National Forests (USFS, 1998) ranged from about 6% to 8% surface fines, with the upper end of one standard deviation values in the approximate range of 15 to 20%. If non-parametric statistical analysis had been performed on this data set, the 75th percentile would be lower than this 15 to 20% range, suggesting an upper range of 10 to 15%. This is based on graphical data presentations from the USFS report and the fact that the low end of one standard deviation is cropped at 0, both of which imply a skewed distribution. The Lolo data set was collected using a comparable methodology to the data collection in Prospect Creek Watershed.

For all Prospect Creek sites where grid toss data were collected, mean percent surface fines < 6.35 mm was 13%, with a median of 6%, standard deviation of 19% and 75th percentile of 14%. These are not true reference values since Prospect Creek is not in reference conditions, but they do represent values that can be attained and may be tracked to indicate potential increased fine sediment inputs.

Based on the reference information and existing conditions in the watershed, a value of 10% < 6.35 mm is used as a target value. Values above the 10% condition indicate increasing fine sediment loading and can be an indicator of negative impacts to a beneficial use.

Table G-1. Reference Data for Grid Toss Surface Fines (< 6.35 mm)

Source	Percent Fines
Blackfoot Headwaters TMDL Reference Condition	6 – 8 (75th percentile)
Lolo NF (USFS, 1998)	6 – 8 (Average); 15 – 20 (upper end of one standard deviation); 10 – 15 probable range of 75th percentiles
Prospect Creek Watershed	13 (Average); 6 (median); 32 (upper end of one standard deviation of 19); 14 (75th percentile)

Percent Substrate Fines < 6.35 mm in Pool Tails (McNeil core)

Table G-2 presents reference data for substrate fines. DEQ and the Flathead National Forest established McNeil core percent fine reference conditions for the Big Creek TMDL of less than or equal to 30 % substrate fines (< 6.35 mm) for a McNeil core sample. This was based on historical data from Big Creek. Other reference conditions are based on local or regional reference conditions typically in the range of 28 to 35% fines < 6.35 mm. These reference conditions are generally based on a 75th percentile or upper end of a reference range.

Results from McNeil Core sampling by the Kootenai National Forest show average percent substrate fines at reference sites monitored from 1997 – 2003 ranged from 17 to 29% with similar median values **(Table G-2)**. The 75th percentile values typically fall below 28%, and the 25th percentile values are all greater than 15%.

Research in the Blackfoot watershed between 2003-2005 show average percent substrate fines at all monitored sites had a median value of 30%. The 75th percentile values averaged 38% and the 25th percentile averaged 26%. Because the majority of sites were not considered reference, the 25th percentile is the most appropriate value to consider for desired condition.

These data is considered a reasonably applicable representation of expected conditions in Prospect Creek. Therefore, a McNeil Core sample target value of less that 28% substrate fines < 6.35 mm is selected using a regional reference primary approach.

Table G-2. Reference Data for Substrate Fines (< 6.35 mm) Using McNeil Core Sampling

Source	**Percent Fines**				
Big Creek (Flathead)	30 (based on average plus one standard deviation)				
Blackfoot Watershed	26 (based on 25th percentile of entire data set)				
TMDL Targets from Other Watersheds in Western Montana	28 – 35 (generally based on 75th percentile or upper end of reference range)				
Kootenai Sampling (1997-2003)	**Average**	**Stnd Dev.**	**25th Percentile**	**75th Percentile**	**Median**
• Bear Creek	19.0	6.0	16.7	22.5	19.5
• Flattail Creek	26.7	7.2	23.2	28.3	26.0
• Himes Creek #1	29.1	4.4	26.4	28.2	27.5
• Libby	25.4	4.5	24.4	27.9	26.0
• West Fork Quartz (Upper)	17.1	3.6	15.2	18.0	16.5
• Upper Silver Butte	21.0	4.3	19.2	23	21.5

Pool Frequency

Reference values for pool frequency are based primarily on interim INFISH Riparian Management Objectives (RMOs) from the National Forest (USFS, 2000) and reference data from the Lolo National Forest (Riggers et al., 1998). The development of pool reference values is focused on identifying a reference range, with focus on the minimum level that should exist to fully support cold-water fish. Higher the pool frequency typically equates to better habitat conditions. Therefore, values above the high end of the reference range would be desirable in most situations, and values below the low end suggest a potential problem.

Based on interim INFISH Riparian Management Objectives (RMOs) from the National Forest (USFS, 2000) and a review of stream width data for Prospect Creek, pool frequency reference development was broken into two categories for applying pool reference conditions to streams in the Prospect Creek Watershed. These categories include: 1) B and C stream types of Prospect Mainstem and 2) B and C stream types of tributary streams. B channels are characterized by moderate sinuosity (>1.2), moderate width/depth ratios (>12), moderate entrenchment ratios (1.4-2.2) and a slope of .02-.04. C channels have less slope (<.02), typically greater sinuosity than B channels, slight entrenchment (>2.2) and moderate to high width/depth ratios (>12).

For Prospect Mainstem, the target pool frequency value is 26 pools per mile based on RMO of 26 pools per mile for streams with wetted width of 50 feet. For tributaries to Prospect Creek, the target pool frequency value range is 47 pools per mile. The tributary pool frequency target is based on the RMO of 47 pools per mile for streams with wetted width of 25 feet. Additional reference data from Riggers et al., 1998 suggest that for pool frequency, the 75th percentile in undeveloped watersheds is 66 pools per mile. 47 pools per mile should be considered the minimum target with a desire to achieve greater numbers close to or exceeding 66 pools per mile.

Width-to-Depth Ratio

Reference data sets for width-to-depth ratio include the Lolo National Forest information (USFS, 1998), reference summary data from the Kootenai National Forest (unpublished data, 1998), stream classification criteria and results from within the Prospect Creek Watershed. **Table G-3** provides a summary of the reference information considered.

Historical and existing stream width information from aerial reviews (RDG, 2004) show an increase in stream width from 1947 to 2000. This information from the aerial assessment work provides an important indicator of width-to-depth changes over time since a significant increase in width can indicate a significant increase in width-to-depth. This is in realization of the fact that in 1947 the stream may have already been overly wide due to human impacts prior to that date. These are not true reference values since Prospect Creek is not in reference conditions, but they do represent values that can be attained and may be tracked to indicate potential increased fine sediment inputs.

Based on the reference information considered, selected target values for width-to-depth ratio include less than 30 for B and C reaches of mainstem Prospect Creek and less than 20 for B and C reaches of tributary streams.

Table G-3. Width-to-Depth Ratio Reference Sources and Results

Data Source	Stream Types & Other Stratification	Results (feet)
Lolo National Forest Reference Streams (Riggers, et al., 1998) (recommended ranges based on reference data sets)	B3 & B4 C3 & C4	12 – 22 10 – 33
Kootenai National Forest Reference Data	B3 (stream widths 18 ± 9) B4 (stream widths 13 ± 4) C3 (stream widths 26 ± 4) C4 (stream widths 15 ± 3)	20.9 ± 9.0 (n = 34) 19.4 ± 6.9 (n = 22) 16.0 ± 7.4 (n = 4) 14.7 ± 3.2 (n = 3)
Rosgen, 1996	B C	12 - 40 12 - 40
Aerial Assessment Data for Mainstem Prospect Creek	C -> D C -> D C -> D	Mean width changes from 1947 to 2000: Reach 2 – 141 to 163 Reach 3 – 126 to 148 Reach 4 – 60 to 68

Sinuosity

Reference data sets for sinuosity reference include Rosgen stream classification criteria (Rosgen, 1996) and existing and historical conditions from within the Prospect Creek Watershed.

Based on the Rosgen stream classification B and C stream types should typically have a sinuosity greater than 1.2.

Historical and existing sinuosity information from aerial reviews (RDG, 2004) shows an decrease in stream width from 1947 to 2000. These are not true reference values since Prospect Creek is not in reference conditions, but they do represent values that can be attained and may be tracked to indicate potential increased fine sediment inputs. Even in 1947 the stream had been impacted by channelization, suggesting the possibility of even higher sinuosity values prior to 1947.

Based on the reference information considered, selected target values for sinuosity range from 1.2 to 1.4.

Table G-4. Sinuosity Reference Sources and Results

Data Source	Stream Types	Sinuosity

Table G-4. Sinuosity Reference Sources and Results

Data Source	Stream Types	Sinuosity
Rosgen, 1996	B C	> 1.2 > 1.2
Aerial Assessment Data for Mainstem Prospect Creek (RDG, 2004)	 C -> D C -> D C -> D	Sinuosity changes from 1947 to 2000: Reach 2 – 1.15 to 1.06 Reach 3 – 1.25 to 1.14 Reach 4 – 1.16 to 1.08

Riffle Stability Index

Kappesser (2002) examined the relationship between particle size distribution in riffles and the size of largest mobile particles found on nearby bars. The “Riffle Stability Index” (RSI) developed by Kappesser provides a means of evaluating sediment loading to mountain streams. The RSI value is the percent-finer than value from the riffle percent-finer than distribution curve that corresponds to the geometric mean particle size of the bar particles.

RSI values below 40 (<40% of channel substrate is smaller than the geometric mean of the largest mobile bar particles) suggest channel scour exceeds sediment loading, indicating degradation.

RSI values between 40 and 70 (40 to 70% of channel substrate is smaller than the geometric mean of the largest mobile bar particles) suggests channel scour and sediment loading are somewhat balanced, indicating dynamic equilibrium..

RSI values above 70 (>70% of channel substrate is smaller than the geometric mean of the largest mobile bar particles) suggest excess sediment loading.

Based on this information, selected target value range for RSI in Prospect Creek is 40 to 70.

Large Woody Debris

Reference information on large woody debris from several sources was considered. Sources included reference data from Swan River TMDL, Plum Creek Timber Company Habitat Conservation Plan (Plum Creek Timber Company, 2000), unpublished data from Plum Creek Timber Company, Lolo National Forest information (USFS, 1998), unpublished data from the Kootenai National Forest, and interim INFISH Riparian Management Objectives (RMOs) from the National Forest (USFS, 2000). **Table G-5** provides a summary of the reference information considered.

Streams were broken into the same size categories for developing and applying LWD reference values. Similar to pool frequency, greater numbers of LWD typically equate to better habitat conditions. Therefore, values above the high end of the reference range would be considered desirable in most situations, and values below the low end of the reference range would typically

be considered undesirable. The Forest Service RMO of greater than 20 pieces per mile is not protective given the much higher range of values from the other reference results.

Table G-5. Large Woody Debris Reference Sources and Data

Source	Stream Order and/or Type (Bankfull Width)	LWD pieces/mile (not including aggregates)			
Swan River Tributaries: Jim, Goat, Piper, and Elk Creeks	B & C, 19'-35' (generally 3rd and 4th order)	Range: 105-734 25th Percentile: 158 75th Percentile: 507 Median: 259 Average: 336			
Four Swan River Tributary Reaches in Jim, Goat, and Elk Creeks;	B & C, 35'-45', (generally 4th or 5th order)	25th Percentile: 104 75th Percentile: 210 Median: 108 Average: 206			
Plum Creek HCP Target	Various streams east of Cascades	412 ± 301			
Reported in PCTC HCP, 2000	Western Montana Streams	25th to 75th Percentile: 290-820 Median: 450			
Unpublished Plum Creek Data	Various streams east of Cascades	25th to 75th Percentile: 105-450 Median: 290			
Lolo NF Undeveloped Conditions (Riggers, et al., 1998)	2nd Order B & C	Average: 772			
Lolo NF Undeveloped Conditions (Riggers, et al., 1998)	3rd and 4th Order B & C	Average: 156			
Kootenai NF, Libby Ranger District		Range	25th/75th	Median	Average
	B < 20' (10' - 17')	100-660	168/409	293	333
	C < 20 (15' – 19')	68-211	119/191	170	150
	B&C < 20' (10' – 19')	68-660	163/371	252	293
	B > 20 (21' – 26')	12-754	74/451	149	274
	C > 20' (23' – 32')	264-480	321/429	377	374
	B&C > 20' (21' – 32')	12-754	112/443	264	301
Kootenai NF, Rexford Ranger District	<19.7'	181			
	>19.7'	152			
INFSH RMOs	All	> 20			

Target values selected for large woody debris in Prospect Creek are summarized in **Table G-6.**

Table G-6. Summary of LWD Reference Values for Prospect Creek Watershed

Stream Type and Bankfull Width (Stream Order)	LWD / Mile Indicator Range	LWD and/or Aggregates per Mile Indicator Range
B & C streams 10' - 20' (generally 2nd and 3rd order)	163 - 371	228 - 519
B & C streams 20' - 35' (generally 3rd and 4th order streams)	112 - 443	157 - 620
B and C streams 36' - 50',	104 - 210	146 - 294

(generally 4th or 5th order streams)		

Riparian Vegetation

Riparian canopy targets are based on the aerial photo analysis and field verification of percent canopy cover on the Prospect Creek mainstem. Based on the results presented in **Appendix C**, targets were derived for percent canopy cover from sites dominated by a mature tree riparian community, which is the desired and historic condition. Consideration is given to differences in active channel width between upper and lower watershed reaches. Riparian canopy targets are 75% or better for active channel widths ≤75 feet, and 60% for active channel widths > 75 feet.

Macroinvertebrate Populations

Macroinvertebrate metrics are commonly evaluated and used to help with beneficial use support conditions throughout Montana. The DEQ applies standard protocols for evaluating the macroinvertebrate data based on a primary reference development approach that is commonly updated as more information becomes available. No additional reference development is required within this document; any macroinvertebrate results will be subject to standard DEQ protocols for evaluating the data against reference conditions.

APPENDIX H
CULVERT ANALYSIS - PREPARED BY LOLO NATIONAL FOREST WITH REVISIONS BY RIVER DESIGN GROUP AND DEQ

This appendix includes an analysis of potential sediment risk from culvert failures as well as an analysis of fish passage capabilities of a sub-set of culvert-stream crossings in the Prospect Creek watershed. Data were collected and analyzed by Lolo National Forest with additional analysis by DEQ.

Introduction

Spatial analysis of roads and stream GIS layers indicates 307 road-stream intersections within the Prospect Creek watershed. In 2002-2003, these culverts were screened as part of a Forest-wide inventory of culvert fish passage capabilities, and a formal survey was completed at 30 crossings on fish-bearing streams. Fish-bearing streams were defined as those with intermittent or perennial flow and less than 25% gradient. Surveyed culverts represent approximately 9% of the 307 culverts in the Prospect Creek watershed. Culverts were surveyed in each of the Prospect Creek tributary watersheds (**Table H-1 and Figure H-1**). Surveyed culverts are all located on roads within the National Forest boundary or on roads outside the National Forest boundary but maintained by the Forest Service. Data collected include culvert dimensions, average fill height, road width, bankfull width, and other parameters.

Table H-1. Stream Crossing Culverts on Fish-Bearing Streams in Prospect Creek Watershed Surveyed in 2002-2003 as Part of Culvert Fish Passage Analysis

HUC 6 No. (1701021306xx)	HUC 6 Name	GIS Count	Number of Crossings Surveyed	Number of Crossings Surveyed & Included in this Analysis
05	Clear Creek	76	6	6
01	Cooper Gulch	16	6	2
03	Crow Creek	32	2	2
04	Wilkes Creek	17	0	0
06	Dry Creek	23	2	2
07	Lower Prospect	114	9	7
02	Upper Prospect	29	3	3
Prospect Creek HUC 5		**307**	**28**	**22**

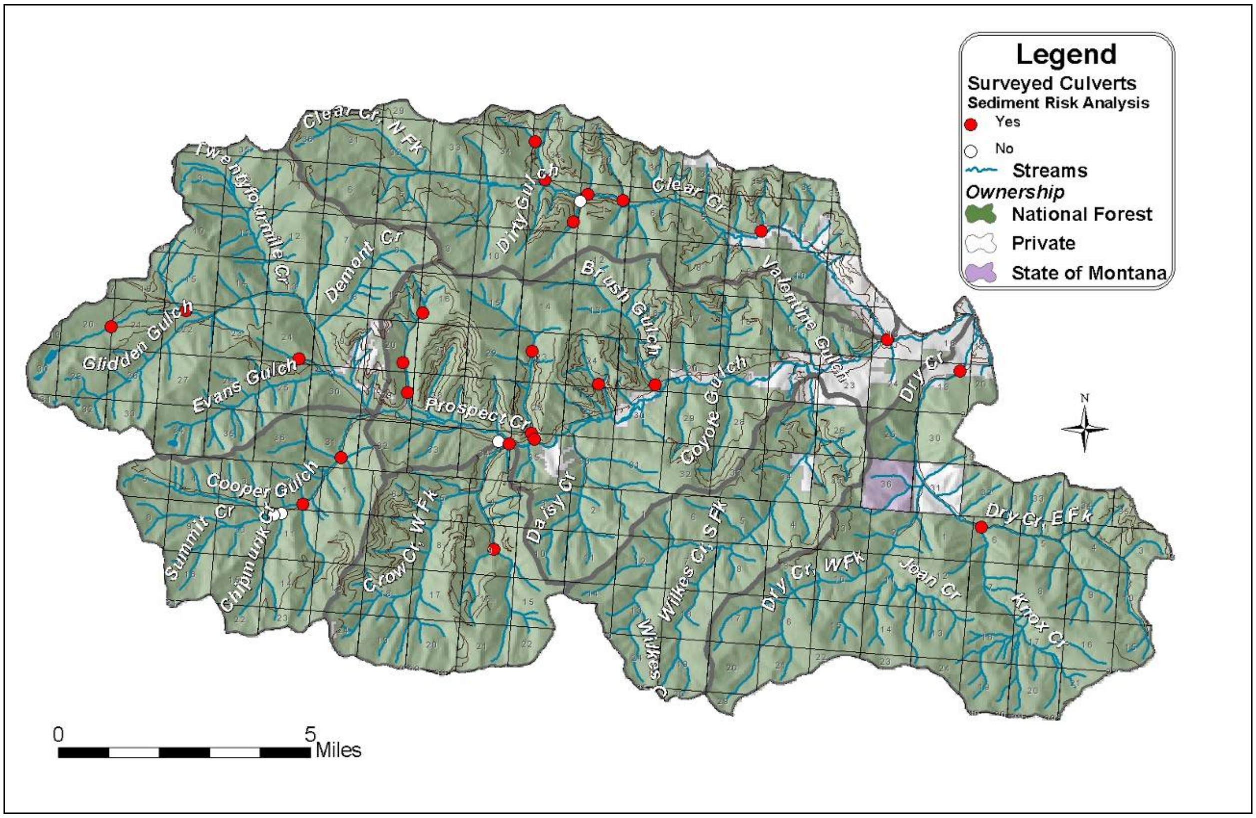


Figure H-1. Stream Crossing Culverts on Fish-Bearing Streams in Prospect Creek Watershed Surveyed in 2002-2003 as Part of Culvert Fish Passage Analysis

The culvert fish passage analysis revealed that almost all of the culverts surveyed span less than the bankfull width of the streams they cross. This relationship is expressed as a ratio of culvert width to bankfull width, also known as constriction ratio or bankfull ratio. Ninety-six percent of culverts surveyed have a constriction ratio less than 1.0 (**Figure H-2**).

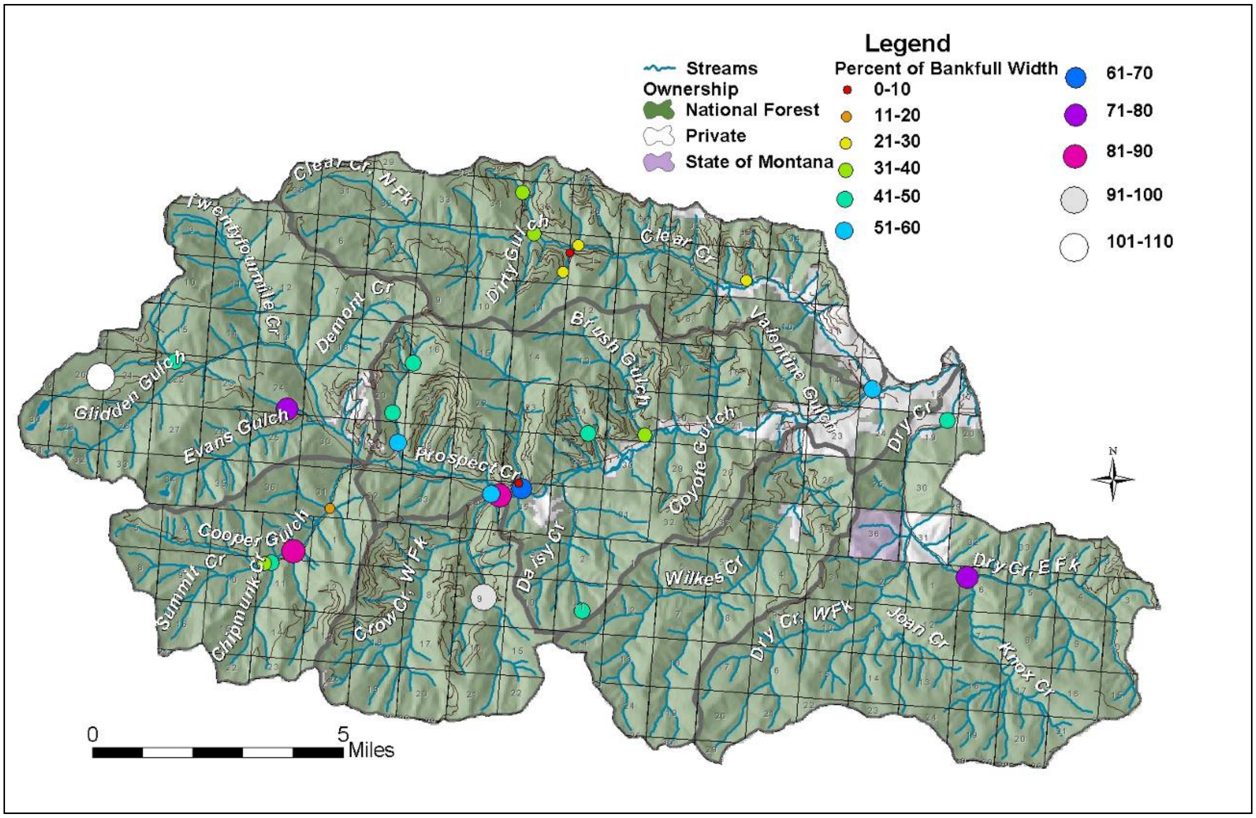


Figure H-2. Surveyed Stream Crossing Culverts by Bankfull Ratio

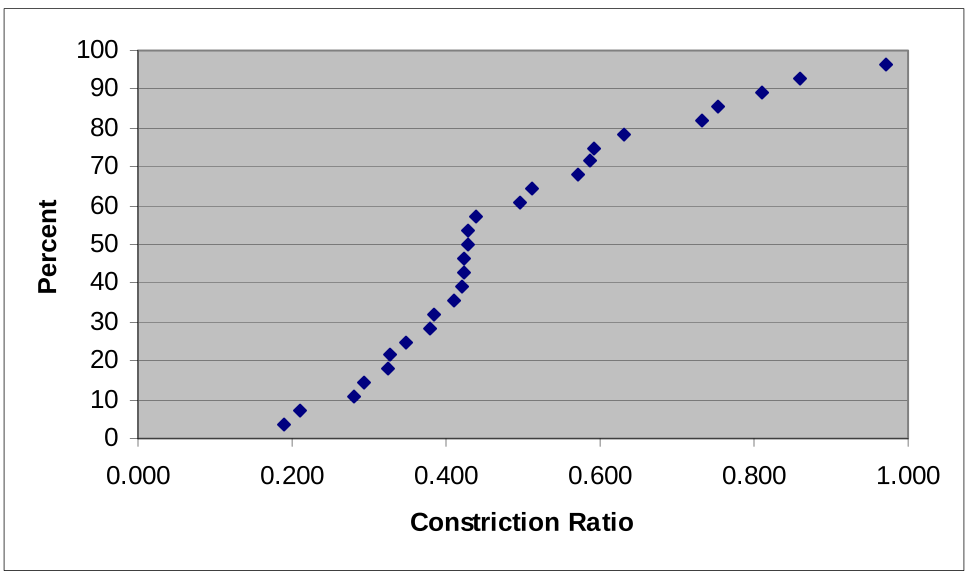


Figure H-3. Cumulative Percent Distribution of Constriction Ratio for Culverts on Fish Bearing Streams in the Prospect Creek Watershed

The ability of fish to pass through a culvert with a corrugated bottom is limited, especially when the constriction ratio is less than one. Fish passage capabilities of 28 crossings were evaluated by modeling with the culvert survey data using Region 1 Fish Passage Evaluation Criteria. Based on analysis of the culvert survey data, 2 (6.6%) of these culverts allow for passage of both adult and

juvenile fish, while 27 (90%) pass neither adult nor juvenile fish. For the remaining culvert (3.3%), passage for adult fish is possible but not for juvenile fish. (**Table H-2 and Figure H-3**).

Table H-2. Fish Passage Capability Results

		Juvenile Fish Passage		
Adult Fish Passage		Green	Natural Simulation	Red
	Green	1	0	1
	Natural Simulation	0	1	0
	Red	0	0	27

Green = hydraulically possible, **Natural Simulation** = conditions are natural (bridge or bottomless arch); passage is possible, **Red** = hydraulically impossible

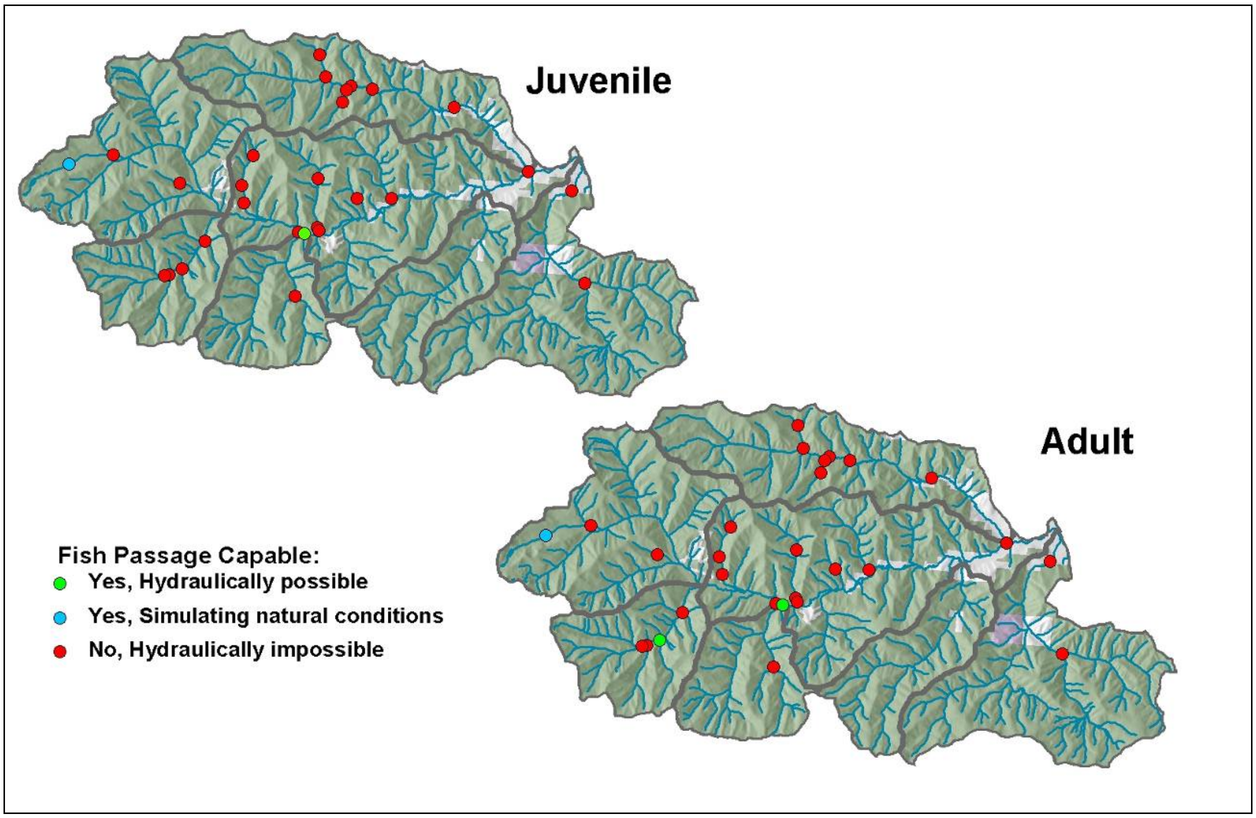


Figure H-4. Map of Fish Passage Capabilities of Surveyed Stream Crossing Culverts in the Prospect Creek Watershed

Not only do undersized culverts often restrict or prohibit fish passage, they are also a potential source of sediment as they are susceptible to failure or blow-out due to the ponding or bottleneck of water at the culvert inlet. Culvert failure results in direct contribution of road fill material to the stream. The following study determined the road fill volume subject to erosion and direct delivery from culvert failure. Modeled discharge and associated headwater depth to culvert depth ratio (Hw:D) was used to assess culvert flow capacities and failure risk. **Table H-3** contains the constriction ratios and associated road fill volume for each surveyed stream crossing.

Table H-3. Constriction Ratio and Associated Road Fill Volume for Surveyed Crossings Included in this Analysis

HUC 6 Name	Stream Crossing	Constriction Ratio	Fill Estimate*
Clear	Clear Creek	0.21	148
Clear	Looters Gulch (Prospect Creek)	0.28	72
Clear	Monroe Gulch	0.33	64
Clear	Monroe Gulch	0.35	73
Clear	Quail Gulch	0.43	30
Clear	Clear Creek	0.59	1993
Cooper	Cooper Creek, Tributary	0.19	91
Cooper	Spokane Creek	0.81	78
Crow	Crow Creek	0.86	439
Crow	Crow Creek, East Fork	0.97	401
Dry	Dry Creek	0.42	1174
Dry	Dry Creek, East Fork	0.73	54
Lower Prospect	Brush Gulch	0.38	24
Lower Prospect	Cox Gulch	0.43	62
Lower Prospect	Cox Gulch	0.50	41
Lower Prospect	Therriault Gulch	0.51	132
Lower Prospect	Cox Gulch	0.57	110
Lower Prospect	Prospect Creek, Tributary	0.59	109
Lower Prospect	Therriault Gulch	0.63	638
Upper Prospect	Prospect Creek, Tributary	0.44	83
Upper Prospect	Evans Gulch, Tributary	0.75	53
Upper Prospect	Prospect Creek	1.06	343
*Assumes 1yd3 = 1 ton.			

Total road fill failure is not always the response to ponded water at the inlet of undersized culverts. In some instances, only part of the road fill may be contributed to the stream as a result of culvert failure. In other cases, culvert failure occurs when ponded water overflows onto the road causing erosion of the road surface.

Methods

The magnitude of peak discharge (Q) for the 2-, 5-, 10-, 25-, 50-, and 100-year recurrence intervals was modeled for each surveyed stream crossing culvert using regression equations developed by Omang (1992). Independent variables in the equations are drainage area (square miles) and mean annual precipitation (inches). Drainage area above each stream crossing was determined using a digital elevation model (DEM) in ArcMap 8.1 Hydrology Tools (ESRI, 2001). Mean annual precipitation for the area drained by each surveyed stream crossing culvert was derived from a GIS raster layer of precipitation (Daly and Taylor, 1998).

Headwater depths (Hw, depth of water ponded at culvert inlet) were determined using software from the US Department of Transportation, Federal Highway Administration (FHWA). The program HDS5eq.exe was downloaded from FHWA’s Hydraulic Engineering Software Archive website (FHWA, 2001). HDS5eq.exe is a nomograph calculator for FHWA “Hydraulic Design of Highway Culverts” (HDS-5) which uses the nomograph charts in HDS-5 Appendix D and inlet control equations found in HDS-5 Appendix A. Based on culvert material, shape, mitering, height, width, discharge, and/or culvert slope, the headwater depth of each culvert was calculated for each modeled discharge.

Analysis of sediment risk from culvert failure was completed for 24 of the surveyed crossing culverts. (Due to incomplete data or double culvert scenarios, 6 of the 30 surveyed culverts were not included in the sediment risk analysis). Modeled discharge, headwater depth to culvert depth ratio (Hw:D), and road fill volume subject to erosion should culvert failure occur were evaluated to determine sediment at risk. If the Hw:D exceeded the recommended Hw:D for a given modeled Q at a particular culvert, the associated road fill volume estimate was counted as a potential sediment contribution. Culverts with Hw:D greater than 1.4 (ponding to the top of the culvert inlet) were considered at risk of failure due to the forces of ponded water at the culvert inlet. It should be noted that culvert failure does not occur every time Hw:D exceeds 1.4. However, corrugated steel pipe manufacturers recommend a Hw:D maximum of 1.5 (ponding 50% above the top of the culvert), and if at all possible less than or equal to 1.0 (American Iron and Steel Institute, 1994). In this analysis, a maximum Hw:D of 1.4 was considered. Culverts capable of passing a given discharge without exceeding Hw:D = 1.4 were considered not at risk to failure and therefore the potential sediment contribution was 0.

Table H-4. Percent of Culverts Surveyed Capable of Passing Flows with HW:D ≤ 1.4

	Hw:Depth	
	< 1.4	**>1.4***
Q2	100	0
Q5	100	0
Q10	92	8
Q25	92	8
Q50	83	17
Q100	75	25

* % of culverts not meeting HW:D <1.4 criteria

Results

As modeled discharge increases, so does the number of culverts incapable of passing the greater discharges. All surveyed culverts evaluated are capable of passing the Q2 discharge with a Hw:D equal to or less than 1.4, while 25% cannot pass Q100 with Hw:D equal to or less than 1.4 (**Table H-4 and Figure H-5**).

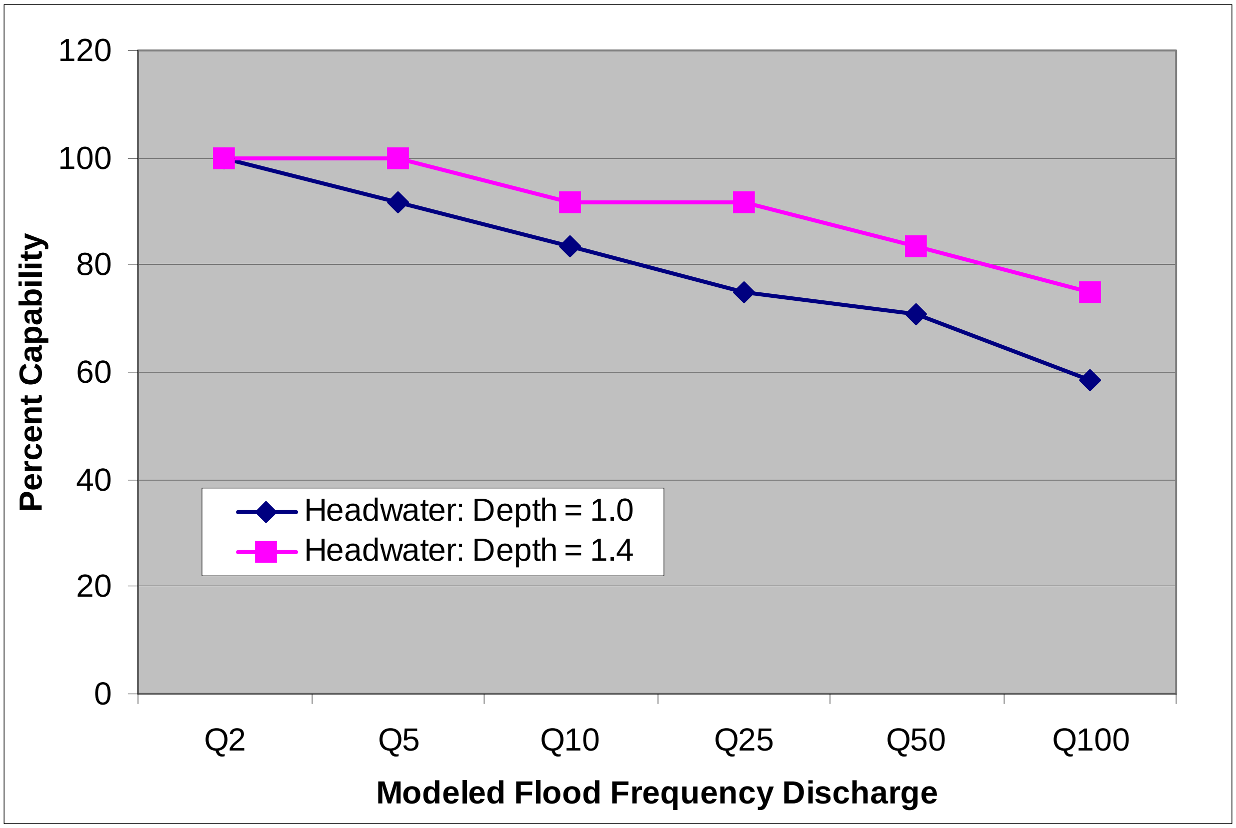


Figure H-5. Percent of Culverts Surveyed Capable of Passing Flows

Potential sediment associated with culvert failure was summarized by HUC 6 under each modeled discharge - headwater to depth ratio combination (**Table H-5**). For the Prospect Creek HUC 5, total potential sediment in a single year ranges from 0 tons for Q2 and Hw:D $\leq$ 1.4 to 1430 tons for Q100 and Hw:D $\leq$ 1.4.

Among the HUC 6 tributary watersheds, distribution of potential sediment from culvert failure is not directly related to the distribution of culverts surveyed. Seven percent (2) of the culverts surveyed are located in the Dry Creek HUC 6 (**Figure H-5**), and account for 90% of the potential sediment from culvert failures in the Prospect Creek HUC 5 at Q100. The remaining potential sediment from culvert failures at Q100 flows respectively is in Clear and Lower Prospect Creek HUC 6 watersheds (**Figure H-6**).

Table H-5. Potential Sediment Contribution (Road Fill Estimate, Tons) at Risk from Culvert Failures Based on Modeled Discharge and Headwater Depth to Culvert Depth Ratio

	Q2	**Q5**	**Q10**	**Q25**	**Q50**	**Q100**
Headwater: Depth	1.4	1.4	1.4	1.4	1.4	1.4
Clear	0	0	0	0	0	136
Cooper	0	0	0	0	0	0

Table H-5. Potential Sediment Contribution (Road Fill Estimate, Tons) at Risk from Culvert Failures Based on Modeled Discharge and Headwater Depth to Culvert Depth Ratio

	Q2	Q5	Q10	Q25	Q50	Q100
Crow	0	0	0	0	0	0
Wilkes	0	0	0	0	0	0
Dry	0	0	1174	1174	1228	1228
Lower Prospect	0	0	24	24	66	66
Upper Prospect	0	0	0	0	0	0
Prospect Creek (HUC 5)	0	0	1199	1199	1294	1430

Numbers Represent Contribution from Surveyed Crossings Only

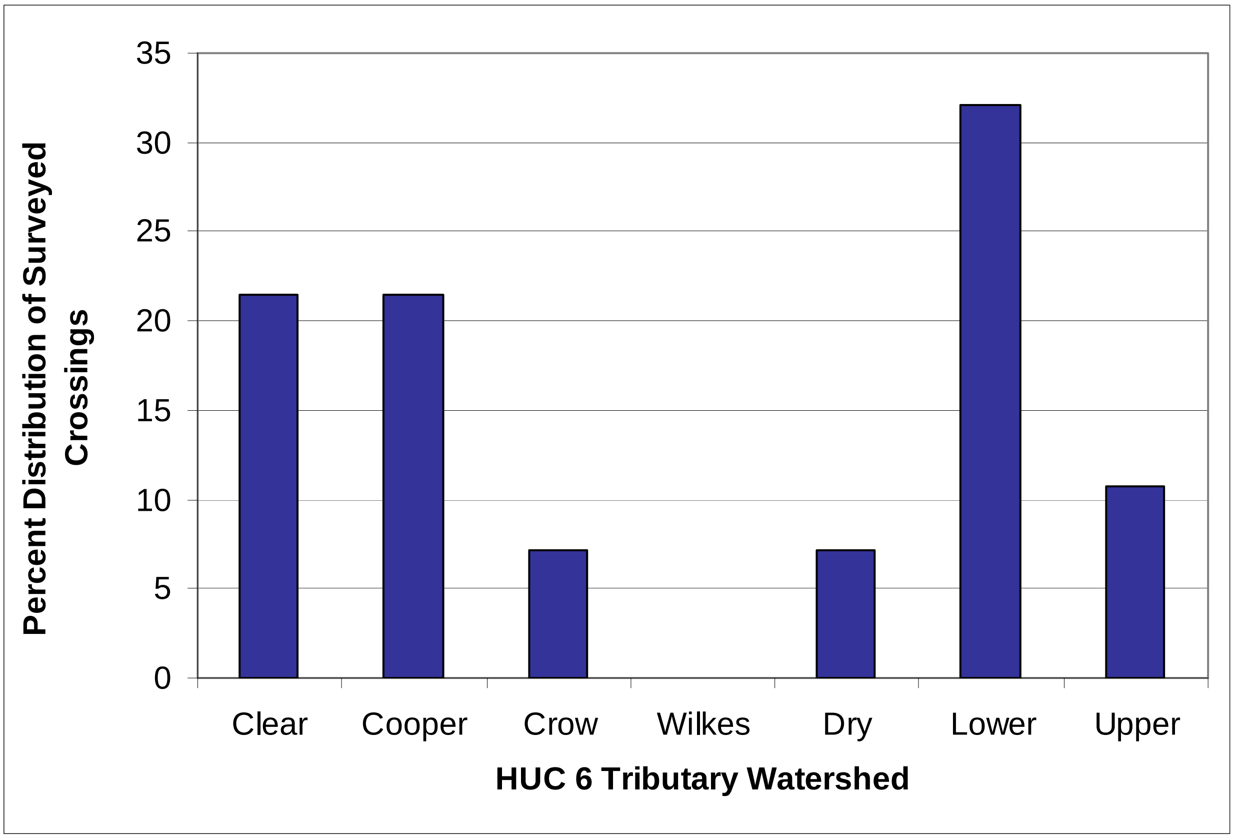


Figure H-6. Distribution Among HUC 6 Tributary Watersheds of all Culverts Surveyed in the Prospect Creek HUC 5

Estimating potential sediment contribution from culvert failure involved determining how much sediment is produced over one hundred years based on flow recurrence probability and the potential sediment load produced by each flow event, and then averaging the loads to provide the potential yearly estimated load. Additionally, it is assumed that not all of the fill at a crossing will enter the stream. An estimated 25% of road fill at an average culvert stream crossing is

assumed to contribute to the sediment load in the Prospect Creek watershed under conditions where Hw:D > 1.4.

The existing culvert failure rate scenario assumes that once a failure occurs the culverts are replaced with the same size (**Table H-5**). The sediment yields from the monitored locations were then extrapolated to the watershed scale (total # of culverts identified through GIS exercise). Culvert failure modeling scenarios were completed to assist in TMDL allocations (**Table H-5**). To determine the appropriate reduction, a scenario was completed by simulating the load if all culverts were upgraded to the Q100 design. This scenario follows the guidance from the USFS Infish recommendations which calls for all culverts on USFS land to be able to pass the Q100 flow event.

Discussion

It is acknowledged that it is not reasonable to expect all culverts to be replaced with a Q100 design immediately and that upgrades will have to occur over time. However, two primary approaches exist to reduce a substantial portion of the risk of potential sediment contribution from culvert failure. One approach is to upgrade all culverts incapable of passing the most frequent flows, or have the most likely potential to fail in the near future. Risk of culvert failure decreases when culverts are capable of regularly passing the most frequent flows, and some larger flows. Another approach is to target those undersized culverts with the greatest amount of road fill at risk in the event of culvert failure. By ensuring that culverts with the greatest amount of road fill are large enough to pass flows, the quantity of potential sediment decreases. The results of this analysis are based on conditions at the time of the study (2003) and do not factor in potential increased flows after timber harvest or forest fires.

In Prospect Creek, both approaches apply to the same culverts. The greatest opportunity for reducing sediment potential under the most frequent flows is in Dry Creek, and is also associated with the largest road fills at risk. The two culverts surveyed in Dry Creek account for 98% of the potential sediment from culvert failure at Q25. Upgrading these undersized culverts to meet at least Q25 would reduce the sediment potential from culvert failure under those conditions by 1174 tons (98% of 1199 tons).

For the purposes of sediment TMDL, an average annual sediment contribution from culvert failure should be determined. One approach to making this determination would be to distribute a portion of the road fill volume at risk in any given year based on recurrence intervals and the likelihood of each event occurring in a given year. The analysis period for this example is 100 years and will use the road fill volumes at risk from **Table H-5** for Hw:D of 1.4.

At the Hw:D of 1.4, the occurrence of a Q2 or Q5 does not put any road fill volume at risk of failure; the occurrence of a Q10 event puts 1,199 tons of fill at risk of failure; as does a Q25 event; and so on (**Table H-5**). The road fill volume at risk under a certain event would include the volume at risk for all smaller events. The occurrence of a Q50 event only increases the load at risk by 95 tons based on1,294 tons minus the 1,199 tons subject to failure under the Q25 and smaller events, (1,294 – 1,199 = 95), and the occurrence of a Q25 event would not increase the load at risk above and beyond that load already at risk from a 10 year event (1,199 – 1199 = 0).

This is because all culverts assessed that could pass a 10 year event with Hw:D > 1.4 could also pass a 25 year event using the same criteria.

In 100 years, a Q2 or greater flow event is likely to occur every two years or 50% of the time. Likewise, a Q5 or greater event is likely to occur every 5 years or 20% of those 100 years, and a Q10 or greater event every 10 years or 10% of the time, and so on. For a Q2 and Q5 event, 0 tons is multiplied by 50 (0 tons); for a Q10 event 1,199 tons is multiplied by 10 (11,990 tons); for Q25, 0 tons is multiplied by 4 (0 tons); and so on. Volume of fill at risk of failure is calculated in this way for each recurrence interval (**Table H-6**). By adding the product values calculated in this way for each recurrence interval, the resulting sum is the volume of fill at risk of failure that is contributed to the stream network over 100 years by the 8% sub-sample of culverts (**Table H-6**).

For the Q100 upgrade scenarios, culvert failure from storm events below the upgrade condition is assumed to occur once before being replaced with the appropriate sized culvert. To determine the fill contributed from these failures, failure at culverts less than the Q100 design is then assumed to occur once, plus an additional time where one failure is likely to occur over 100 years, or a Q100+ event. In this case, the load at risk associated with all culverts less than a Q100 design is 1294 tons. Assuming these all fail once and are then upgraded, this load (1294) is added to the load at risk associated with Q100 failure (1294+136=1430). The total load is then the sum of pre and post upgrade loads (1294+1430=2724).

Table H-6. Cumulative 100 Year Sediment Load Associated with Surveyed Culverts and for Q100 Upgrade Scenario

Q	No Upgrade After Initial Failure	Upgrade to Q100 After Initial Failure
2	0	0
5	0	0
10	11,990	1,199
25	0	0
50	190	95
100	136	1,430
Load (Tons/100 Years)	**12,316**	**2,724**

These results are for the inventoried culverts only. Based on the information in **Table H-1**, the inventoried culverts represent a sub-sample of approximately 8% of the total stream crossing population of 307 crossings.

In order to determine the potential annual sediment load from culvert failure that could occur in the Prospect Creek Watershed, the values associated with the assessed culverts must be extrapolated to all culverts in the watershed. Average annual load per culvert was determined and applied to each culvert for the two culvert condition scenarios (**Table H-7**). The average load per culvert was then applied to the number of culverts within each subwatershed to determine the average annual load per stream from culvert failure (**Table H-8**).

Table H-7. Extrapolition to all Prospect Creek Watershed Culvert

Scenario	Surveyed Culverts	All Culverts	Delivery Factor (0.25)	Avg Annual Load	Avg Load Per Culvert
No upgrade	12,316 ton/100 year	157,546	39,387	394	1.3
Q100 Upgrade	2724 ton/100 year	34,845	8,711	87	0.3

Table H-8. Average Annual Load by Sub-Watershed

Sub-Watershed	# of Culverts	No Upgrade	Q100
Clear	76	99	23
Cooper	16	21	5
Crow	32	42	10
Wilkes	17	22	5
Dry	23	30	7
Upper	114	148	34

Several caveats should be considered when interpreting this analysis. First, the USGS regression equations are subject to large standard errors that at times can substantially over or under predict discharge. Second, the assessment was conducted using a sub-sample of culverts in the Prospect Creek watershed. Because of the relatively small sample size, the entire population of analyzed culverts was used to extrapolate across the Prospect Creek watershed, rather than analyzed culverts from a subwatershed representing that particular subwatershed. It is assumed that all road crossings are managed similarly throughout the Prospect Creek watershed. The sub-sample of culverts used (fish-bearing streams) is biased toward stream crossings on wider, lower gradient streams, with greater discharges (hence the likelihood of bearing fish). The unsampled population of culverts typically occurs on narrower streams with steeper gradients and perhaps smaller discharges, and with larger road fills and smaller diameter culverts. Road fill volume also varies according to stream size and hillslope gradient.

Another important fact to consider is that the load associated with a Q100 design assumes failure at the Q100 flow, yet the desired scenario is that all culverts are upgraded to the Q100 flow design. This then implies that even if the Q100 design criteria is met, all culverts will fail at that flow. However, the recurrence interval "Q100" simply means the flow associated with the Q100 flow event, *or greater*, is likely to occur once in 100 years. Realistically, culvert design to meet the Q100 flow or better is the optimal condition short of constructing a free-span bridge. Large scale flow events that occur once per 100 years however are unpredictable and may be well beyond the Q100 flow. Therefore, even though the culverts are upgraded to meet the Q100 design flow, which is a static value, the actual Q100 event could well exceed the capacity for that design and thereby the loads associated with those culverts would still be at risk. Nevertheless, meeting the Q100 design criteria drastically reduces the sediment load that would be attributed to culvert failure in the watershed,

Also important to consider is the short-term sediment contribution that results from disturbing the existing roadbed to remove and replace undersized culverts with larger culverts. Based on previous Lolo National Forest Monitoring Reports and other research the short-term sediment pulse is expected to be about 2 tons per culvert during the first 24 hours during and after culvert replacement (USDA, 1999). Most of the sediment increases passes within 24 hours, and decays to near normal levels within one year. Mitigation measures such as diverting live water, using filter cloths, slash filter windrows, and straw bales, and seeding and fertilizing can reduce this sediment increase up to 80 percent (Wasniewski, 1994).

Based on the culvert-failure analysis and extrapolation presented, the risk of sediment contribution potential culvert failures can be reduced. The restoration objective is to, at a minimum, upgrade all culverts to meet Q100 with Hw:D of less than 1.4.

After meeting Q100 capabilities, load at risk would increase with the addition of new stream crossings and/or replacement of existing stream crossings that are undersized for any flow. These situations and resulting recommendations are addressed in the allocations and implementation sections of this document (**Sections 6.0 and 8.0**). If new undersized crossings are established then existing undersized crossings should be upgraded or removed to equally compensate for the increase in road fill at risk from the new crossing structure.

Consideration in culvert sizing must also be given to fish passage, the geomorphic effects such structures have on stream channels including sediment load (bank erosion and channel scour) and effects to fish habitat.

REFERENCES

American Iron and Steel Institute. 1994. Handbook of Steel Drainage & Highway Construction Products. Fifth ed. Washington D.C.: American Iron and Steel Institute.

Daly, C. and G.Taylor. 1998. Montana Average Annual Precipitation, 1961-1990. (PRISM). Corvallis, OR: Oregon State University http://nris.mt.gov/nsdi/nris/shape/precip.zip. http://nris.state.mt.us/nsdi/nris/precip.html

Environmental Systems Research Institute . 2001. ArcMap 8.1. Redlands, CA: Environmental Systems Research Institute.

Federal Highway Administration. 2001. HY 8 - HDS 5 Appendix D Chart Calculator. www.fhwa.dot.gov/BRIDGE/hydsofta.htm

Omang, R.J., 1992. Analysis of the Magnitude and Frequency of Floods and the Peak-Flow Gaging Network in Montana. *U.S. Geological Survey Water-Resources Investigations Report*: 92-4048

U.S. Forest Service. 2003. Region 1 Fish Passage Evaluation Criteria. Northern Region. Missoula, MT: U.S. Forest Service.

U.S. Forest Service. 1999. Forest Plan Monitoring and Evaluation Report. Missoula, MT: Lolo National Forest.

Wasniewski, L. 1994. Hillslope Sediment Routing Below New Forest Roads in Central Idaho. MS thesis. Oregon State University.

APPENDIX I
TEMPERATURE FACTORS

Introduction

Although not a listed pollutant on the 2006 303(d) list, temperature is an important water quality concern for the fisheries in the Prospect Creek watershed. Factors affecting temperature are discussed in other sections of this document: roads and utility corridors (**Appendix B**), stream flow and aggraded conditions as related to width-to-depth ratio (**Appendix F**) and riparian vegetation (**Appendix C**).

Methods

Katzman (2003) collected water temperatures in three locations on mainstem Prospect Creek. Monitoring locations include: upstream of Cooper Gulch, 24 km upstream from the Prospect Creek mouth and upstream from Demont Creek, approximately 28.2 km upstream from Prospect Creek mouth. Based on the temperature data, Katzman concluded that Prospect Creek likely exceeds bull trout rearing temperatures at all locations on the main stem, particularly in the lower drainage where the maximum and average water temperatures were 63.3°F and 55.8°F respectively, between March and November of 2000 (RDG, 2004).

DEQ collected temperature data in 2002 and 2003. Data loggers were installed in mainstem Prospect Creek and major tributaries supporting bull trout including Clear, Cooper, Crow, Dry, Twentyfourmile, and Wilkes creeks. A list of temperature loggers, locations and years is included in **Table I-1**. Most data loggers were installed in the early or late part of July and removed in the end of September or early October. Instruments recorded water temperature at half hour intervals continuously each day. Data used for the summary statistics presented in the following figures and tables are complete through a periodicity of 24 hours and does not include partial days (i.e. data taken on the days of instrument installation or removal).

Table I-1. Temperature Loggers in Prospect Creek Watershed

ID	YEAR	LOGGERID	STREAM_NAM	LOCATION_D	LAT	LONG
1	2002	530221	Cooper Creek	1.5 mile up road #7623	47.526107	-115.621807
2	2002	530222	Crow Creek	above mouth,	47.534530	-115.552093
3	2002	530223	Prospect Creek	above Crow, upstream of F.H. 7 bridge crossing and mouth of Crow Creek	47.538470	-115.545522
4	2002	530224	Prospect Creek	above Coyote Creek,	47.562738	-115.455352
5	2002	530225	Wilkes Creek	above trailhead	47.540340	-115.422047
6	2002	530226	Prospect Creek	above Clear Creek, downstream of road #7618 bridge crossing	47.576240	-115.392525
7	2002	530227	Clear Creek	mouth, downstream of F.H. 7 crossing	47.576460	-115.389657
8	2002	530228	Clear Creek	above road #153 switchback, 9.3 miles from F.H. 7	47.612682	-115.549730

Table I-1. Temperature Loggers in Prospect Creek Watershed

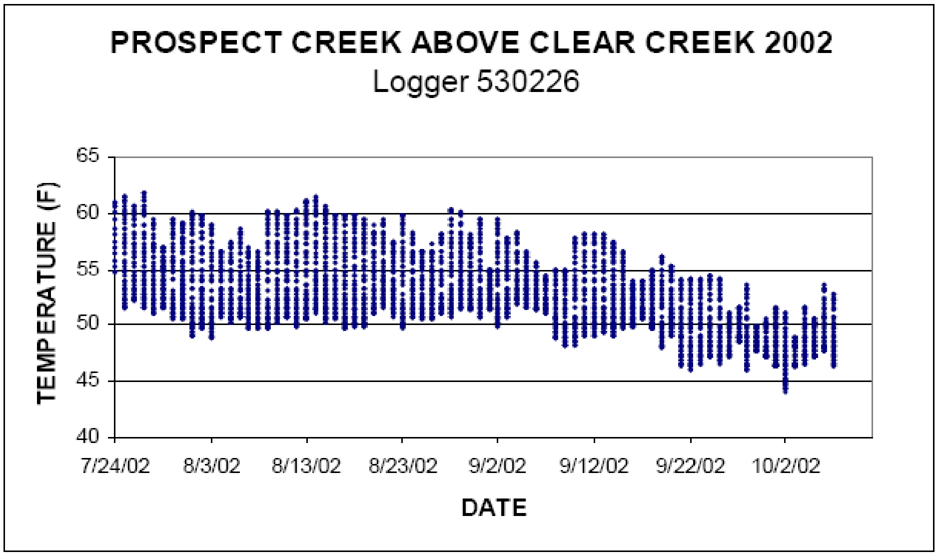
ID	YEAR	LOGGERID	STREAM_NAM	LOCATION_D	LAT	LONG
9	2002	530229	East Fork Dry Creek	above Knox Creek, above CMP crossing at trailhead above Knox Creek mouth, in Section 6	47.525172	-115.343587
10	2002	530230	Dry Creek	mouth of Dry Creek at county road crossing	47.585000	-115.354600
11	2002	476524	Know Creek	200 feet above mouth of Knox Creek at Knox railhead	47.524870	-115.344162
12	2002	476522	Twentyfour Mile Cre	above F.H 7 road crossing just above mouth	47.576905	-115.651978
13	2002	0	West Fork Dry Creek	stolen in 2002, at Section 2 line with private, road #7614	47.528100	-115.371838
0	2003	584788	Prospect Creek	Prospect Creek above 24Mile Creek	47.576520	-115.653270
0	2003	584786	Clear Creek	Clear Creek - Middle	47.605040	-115.446500

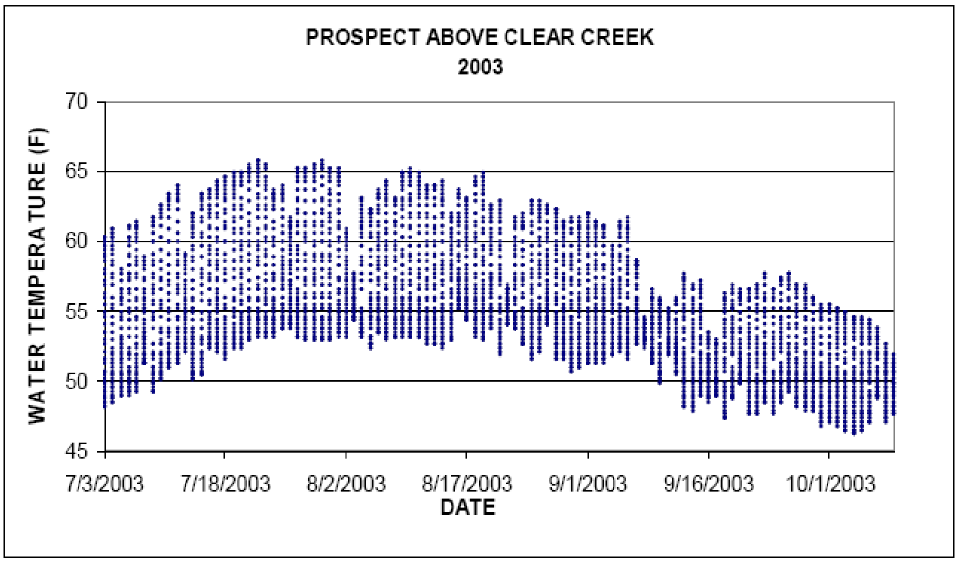
Riparian canopy density was measured for a sub-sample of locations on mainstem Prospect Creek using 1996 aerial photography. Methods are described in RDG 2004 and in **Appendix C**.

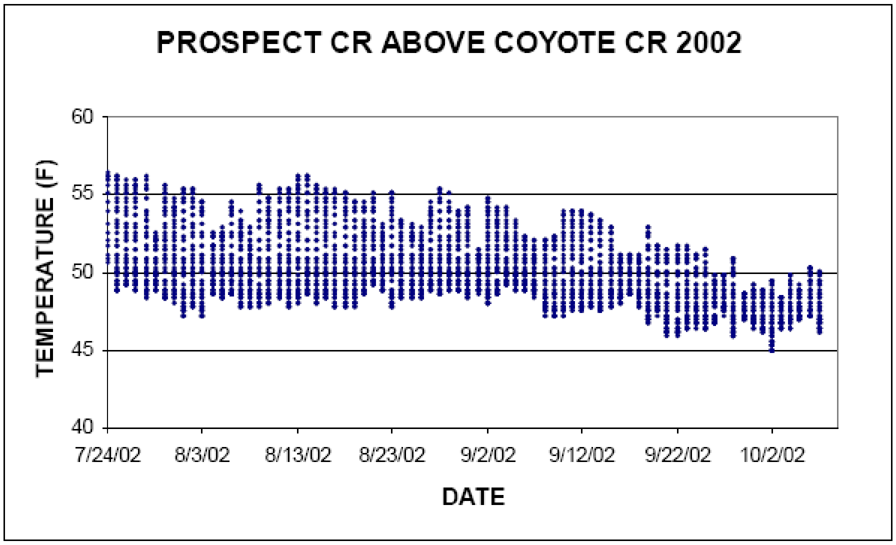
On August 30, 2005, Montana DEQ collected field measurements of riparian canopy density at some of the aerial photo sample sites using the EMAP method (Lazorchak, 2000). A densitometer was used to measure canopy shading the stream at three cross-sections within the aerial photo sample site. Cross sections were located in the middle of aerial photo sample site, at an upstream location within the site each site, and at a downstream location with the site. For each cross-section, a densitometer reading was taken at the left bank, the right bank, and in the middle of the channel. All readings were taken with the densitometer at 1 foot above the water surface,
All values were averaged to determine canopy density for the aerial photo site. (Lindgren, H., 2005)

Results

The results of temperatures collected are presented in **Figures I-1 through I-7. Table I-1** summarizes temperature data from 2000 and 2003. Water temperatures for the main stem of Prospect Creek are compared to the canopy density analysis (**Appendix F**) in **Table I-2**.


PROSPECT CREEK ABOVE CLEAR CREEK 2002
Logger 530226
TEMPERATURE (F)
65
60
55
50
45
40
7/24/02
8/3/02
8/13/02
8/23/02
9/2/02
9/12/02
9/22/02
10/2/02
DATE


PROSPECT ABOVE CLEAR CREEK
2003
WATER TEMPERATURE (F)
70
65
60
55
50
45
7/3/2003
7/18/2003
8/2/2003
8/17/2003
9/1/2003
9/16/2003
10/1/2003
DATE



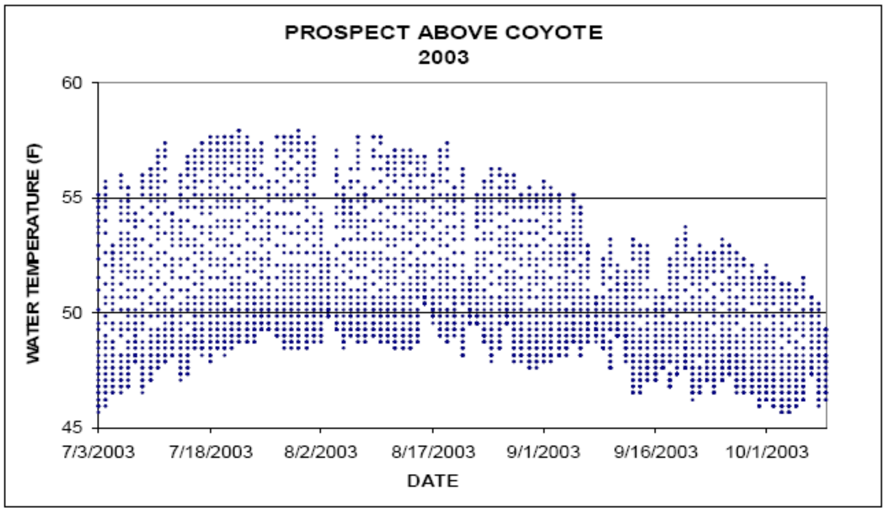
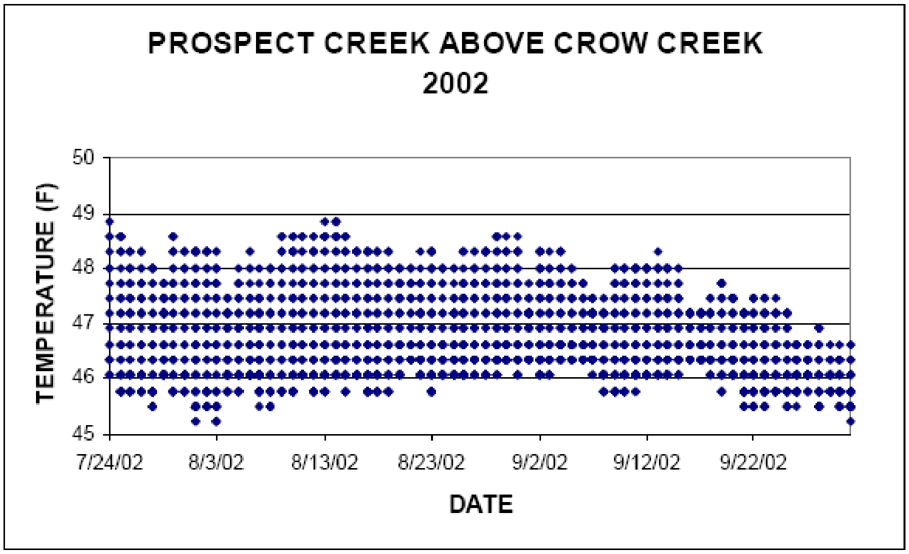
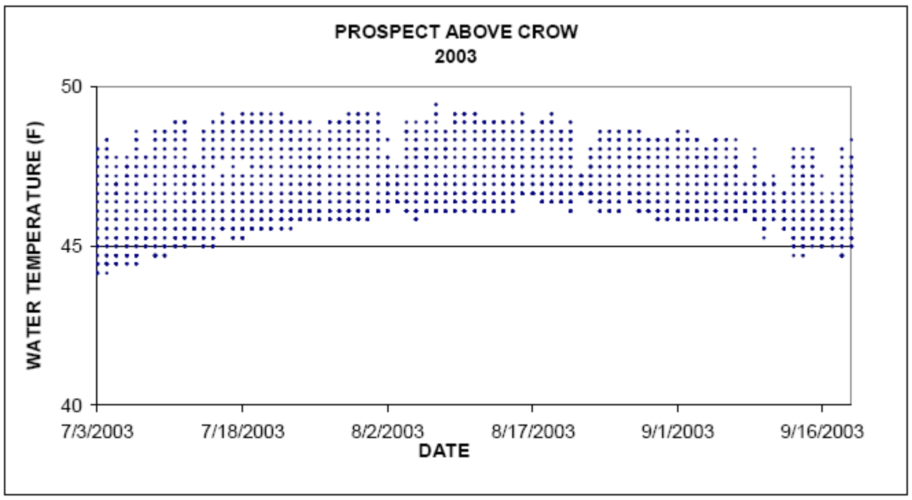


Figure I-1. Range of Temperatures Recorded in a 24 Hour Period from July through October in Prospect Creek Watershed, 2002-2003*

*Top two charts present data from mainstem Prospect Creek, upstream of the mouth of Clear Creek.
*Bottom two charts present data from mainstem Prospect Creek, upstream of the mouth of Coyote Creek.
*Both sites are in Lower Prospect HUC 6.


PROSPECT CREEK ABOVE CROW CREEK
2002
TEMPERATURE (F)
50
49
48
47
46
45
7/24/02
8/3/02
8/13/02
8/23/02
9/2/02
9/12/02
9/22/02
DATE


PROSPECT ABOVE CROW
2003
WATER TEMPERATURE (F)
50
45
40
7/3/2003
7/18/2003
8/2/2003
8/17/2003
9/1/2003
9/16/2003
DATE

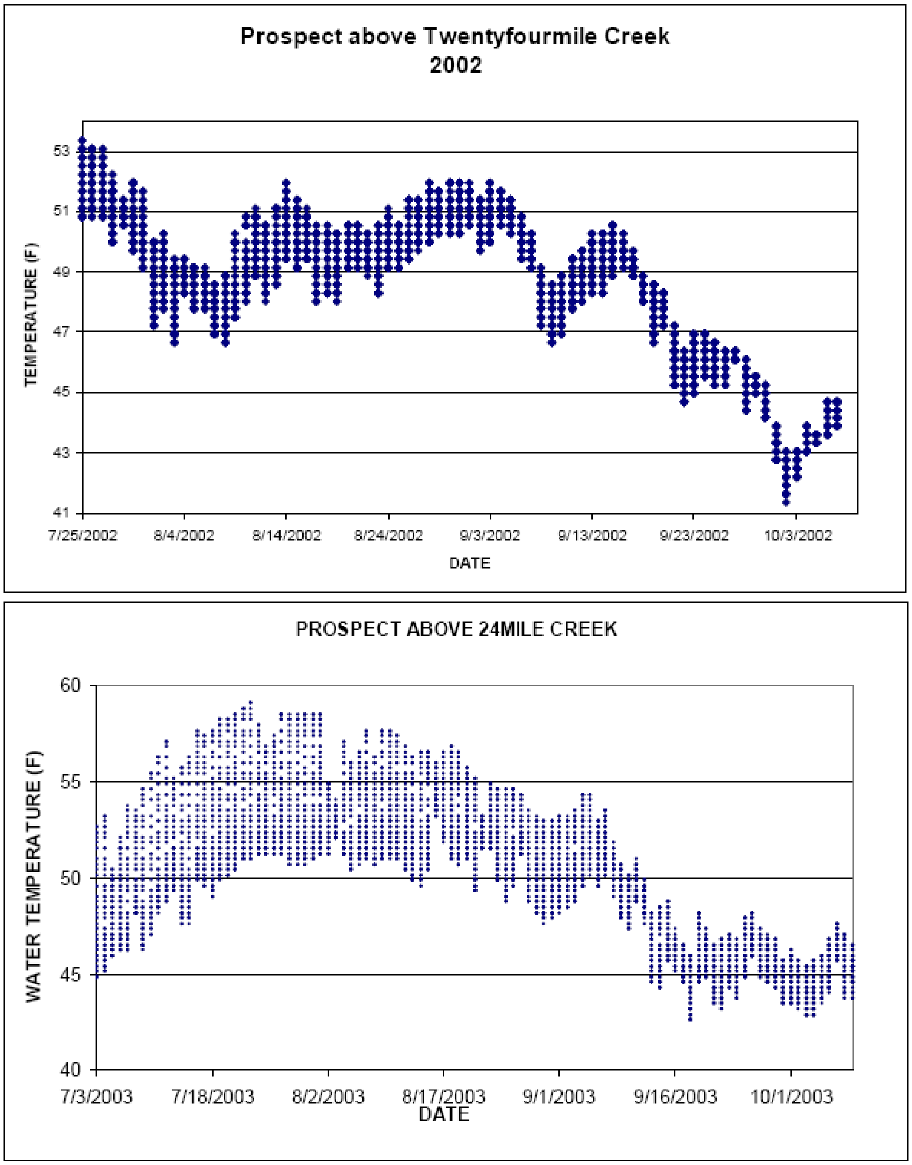
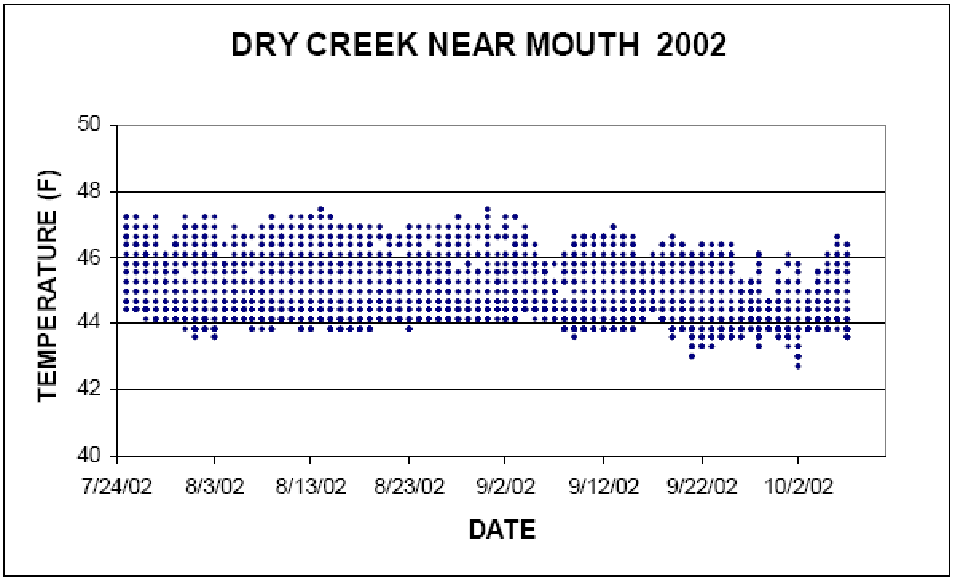
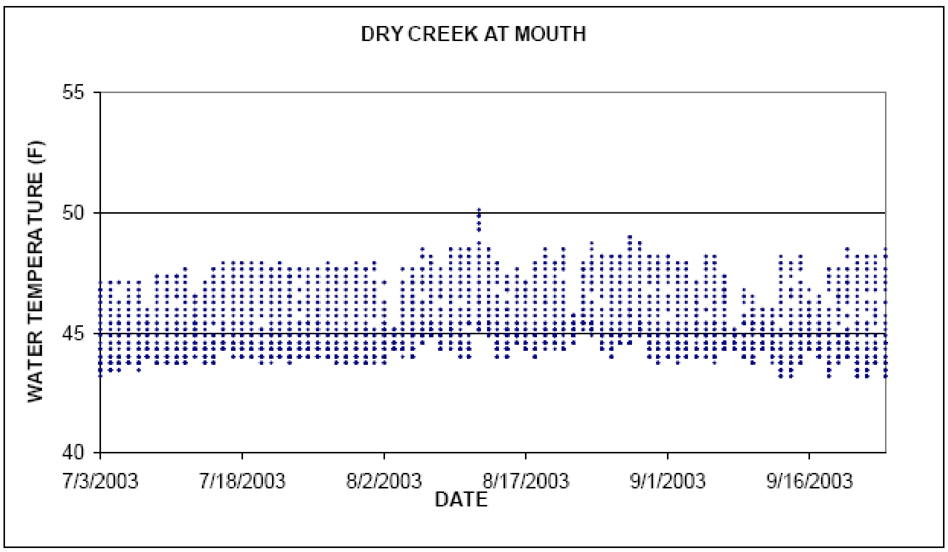
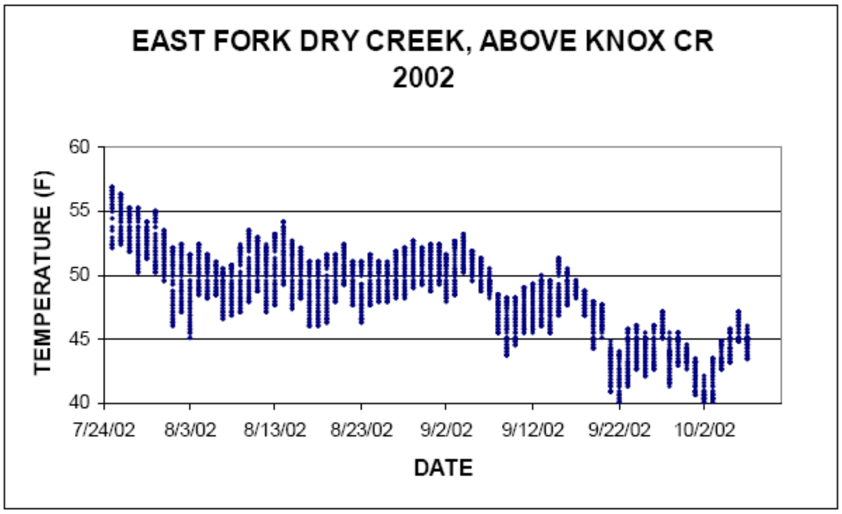


Figure I-2. Range of Temperatures Recorded in a 24 hour Period from July through October in Prospect Creek Watershed, 2002-2003*

*Top two charts present data from mainstem Prospect Creek, upstream of Crow Creek, in Lower Prospect HUC 6.
*Bottom two charts present data from mainstem Prospect Creek, upstream of the mouth of Twentyfourmile Creek, in Upper Prospect HUC 6.


DRY CREEK NEAR MOUTH 2002
TEMPERATURE (F)
50
48
46
44
42
40
7/24/02
8/3/02
8/13/02
8/23/02
9/2/02
9/12/02
9/22/02
10/2/02
DATE


DRY CREEK AT MOUTH
WATER TEMPERATURE (F)
55
50
45
40
7/3/2003
7/18/2003
8/2/2003
8/17/2003
9/1/2003
9/16/2003
DATE



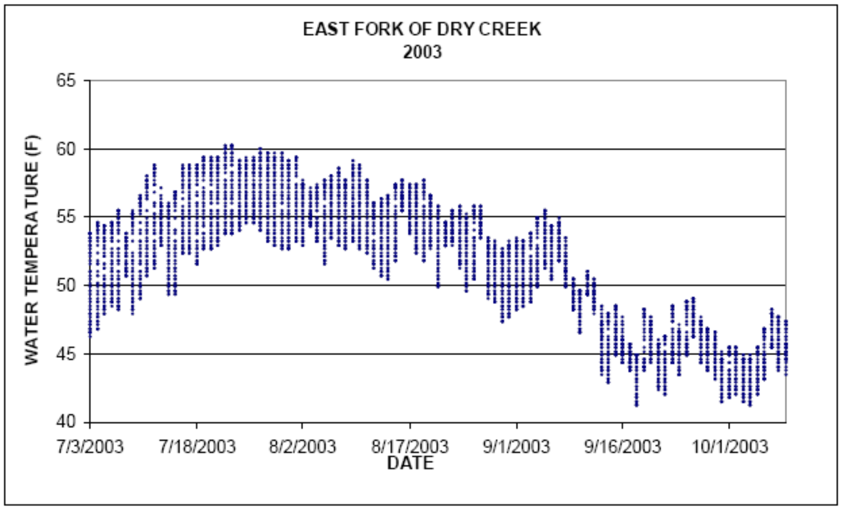
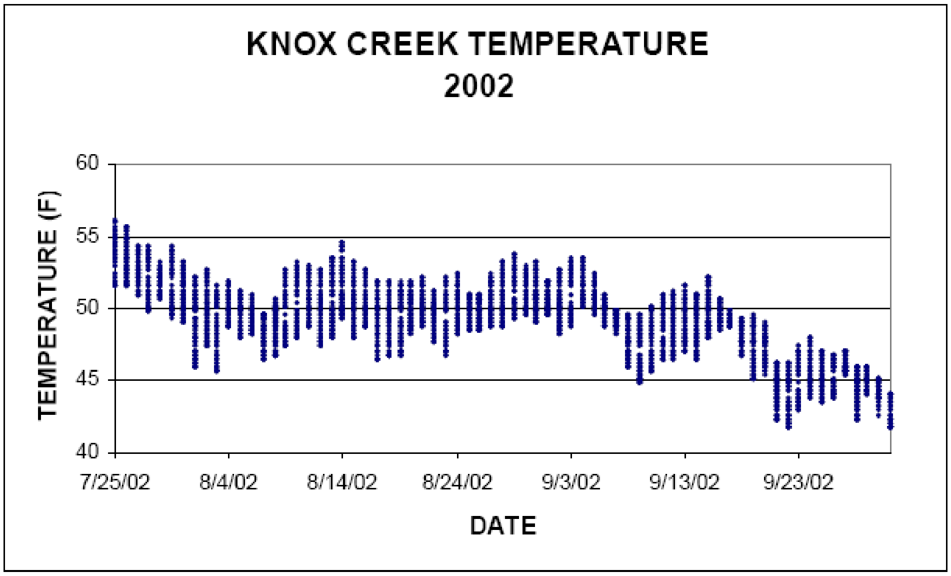
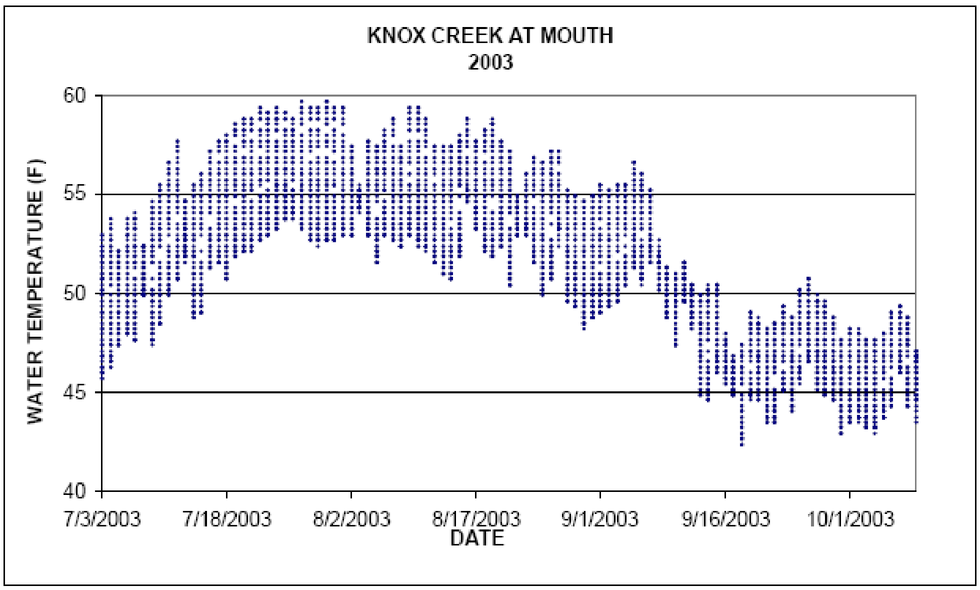
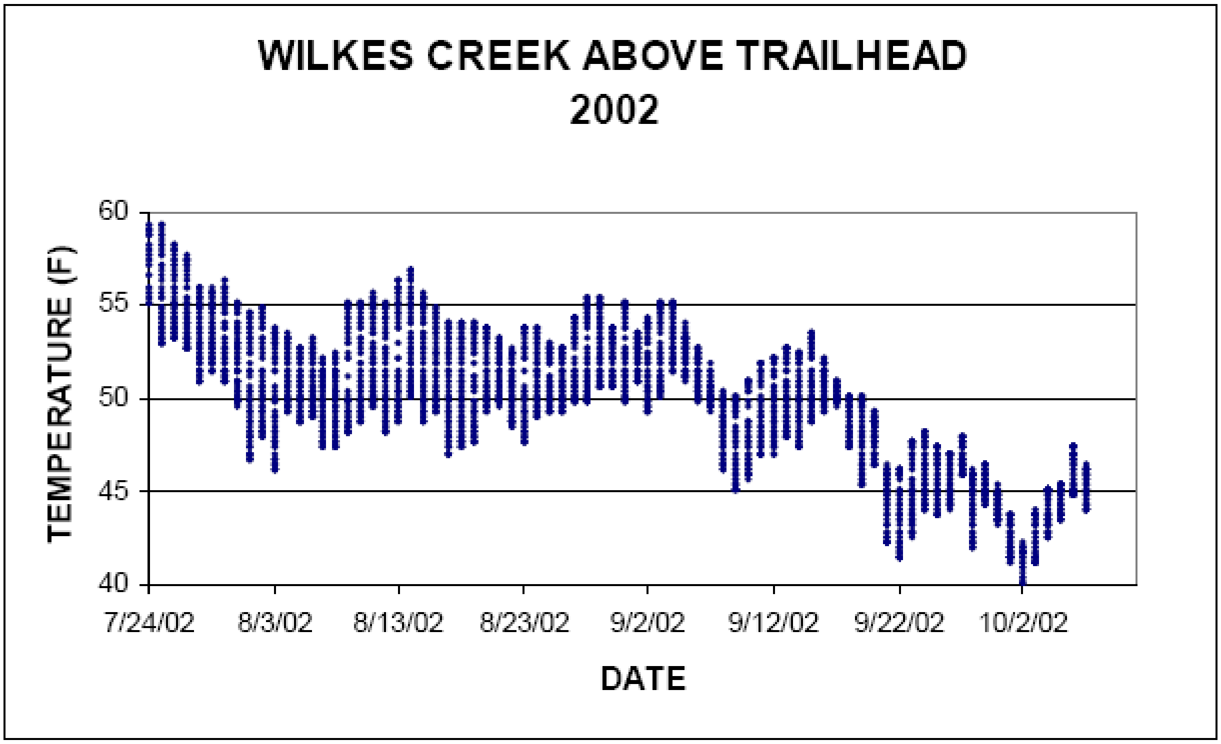


Figure I-3. Range of Temperatures Recorded in a 24 Hour Period from July through October in Prospect Creek Watershed, 2002-2003*

*Top two charts present data from upstream of the mouth of Dry Creek.
*Bottom two charts present data from East Fork Dry Creek upstream of the mouth of Knox Creek.
*Both sites are in Dry Creek HUC 6.


KNOX CREEK TEMPERATURE
2002
TEMPERATURE (F)
60
55
50
45
40
7/25/02
8/4/02
8/14/02
8/24/02
9/3/02
9/13/02
9/23/02
DATE


KNOX CREEK AT MOUTH
2003
WATER TEMPERATURE (F)
60
55
50
45
40
7/3/2003
7/18/2003
8/2/2003
8/17/2003
9/1/2003
9/16/2003
10/1/2003
DATE



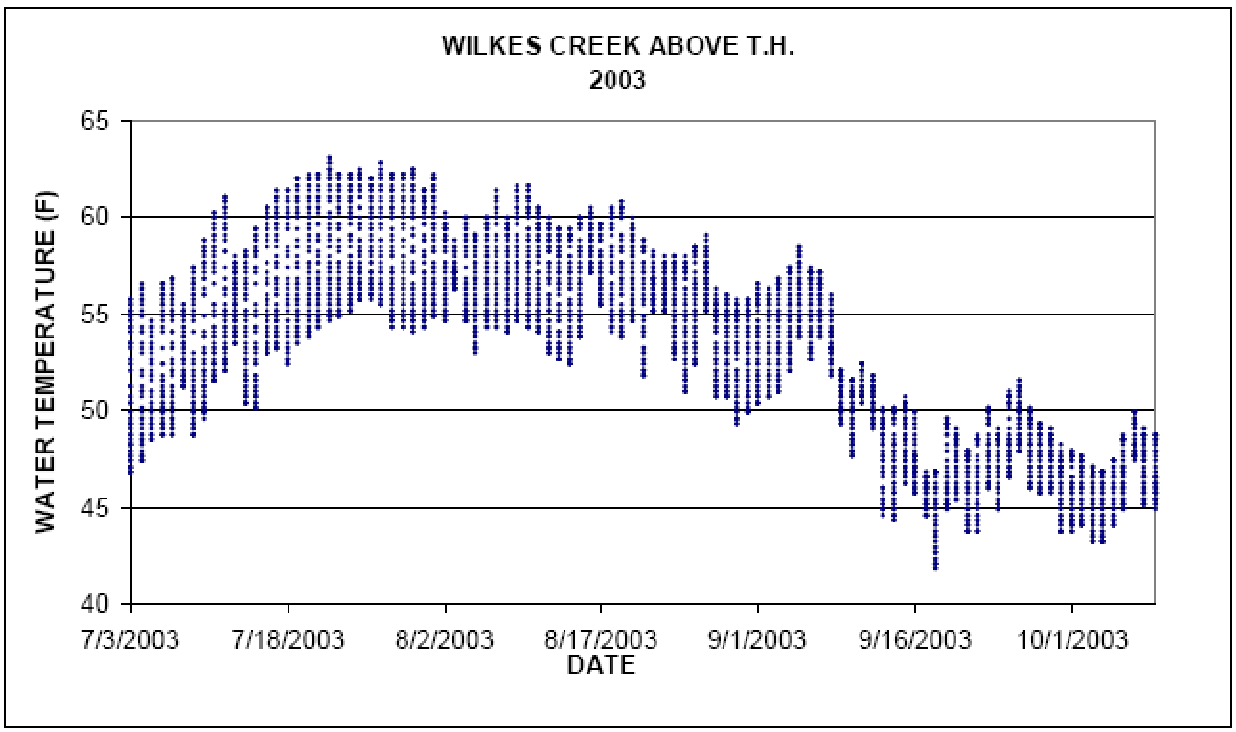
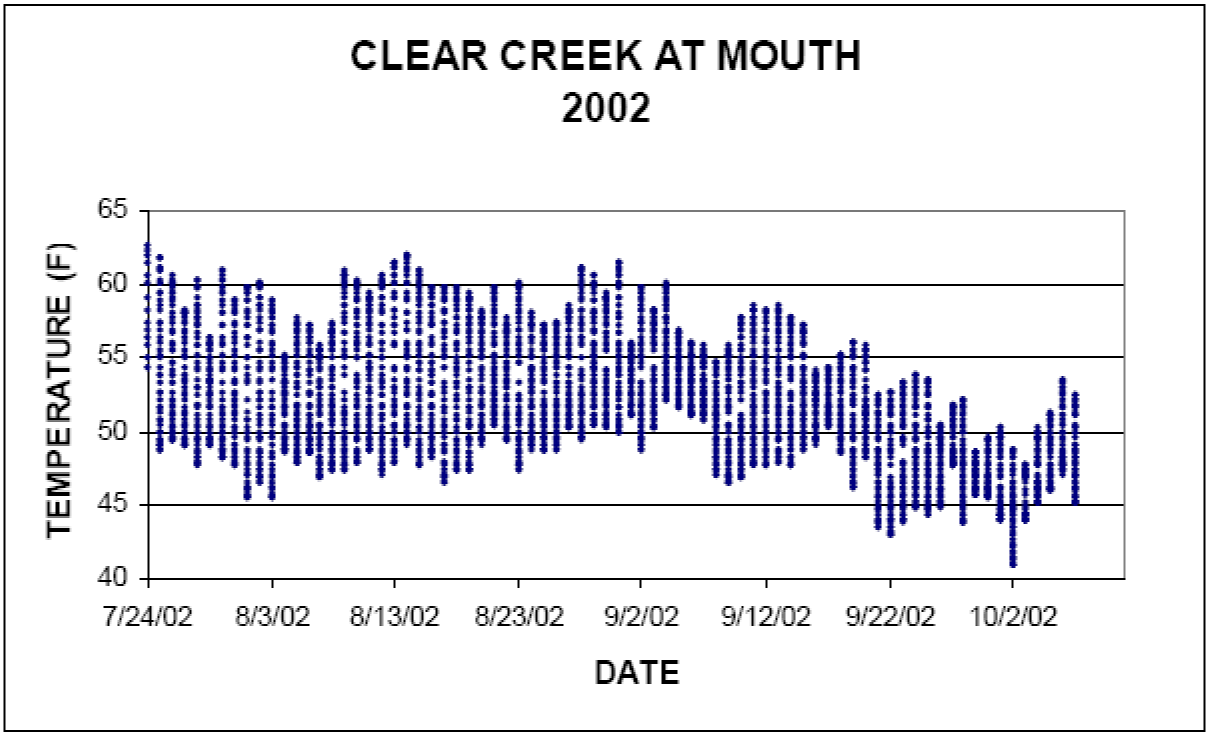
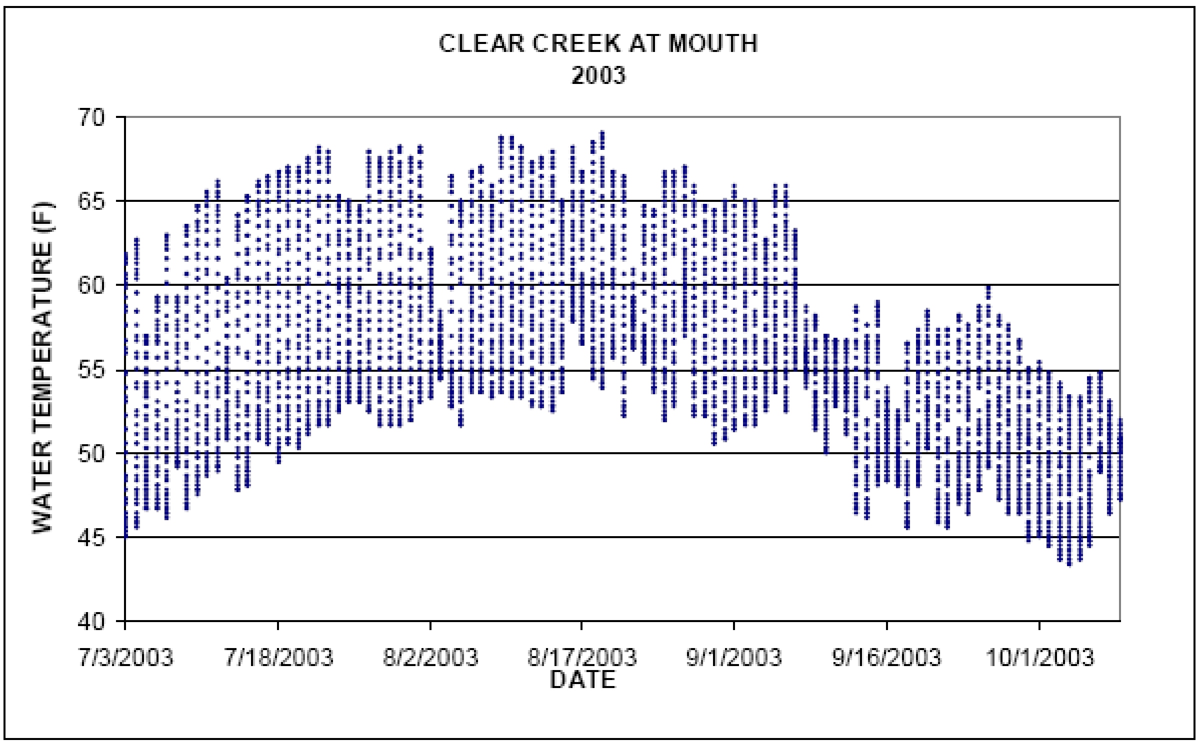
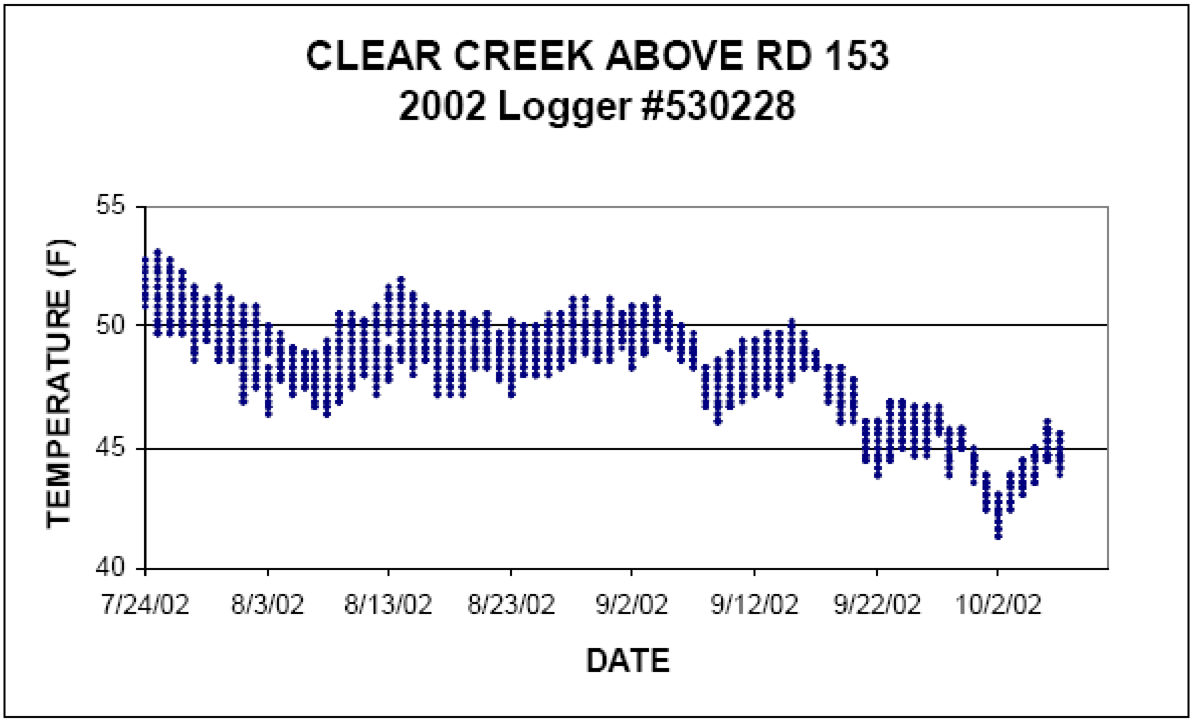


Figure I-4. Range of Temperatures Recorded in a 24 Hour Period from July through October in Prospect Creek Watershed, 2002-2003

Top two charts present data from upstream of the mouth of Knox Creek in Dry HUC 6.
Bottom two charts present data from Wilkes Creek above the trailhead in Wilkes HUC 6.


CLEAR CREEK AT MOUTH
2002
TEMPERATURE (F)
65
60
55
50
45
40
7/24/02
8/3/02
8/13/02
8/23/02
9/2/02
9/12/02
9/22/02
10/2/02
DATE


CLEAR CREEK AT MOUTH
2003
WATER TEMPERATURE (F)
70
65
60
55
50
45
40
7/3/2003
7/18/2003
8/2/2003
8/17/2003
9/1/2003
9/16/2003
10/1/2003
DATE



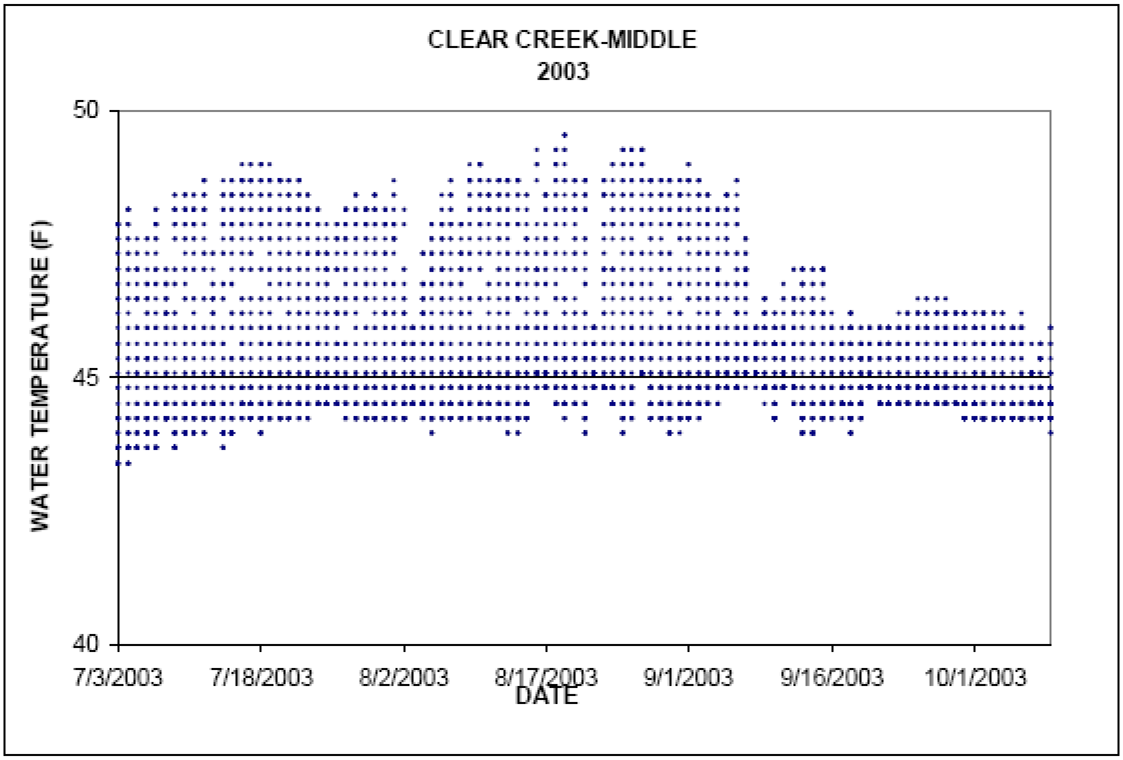
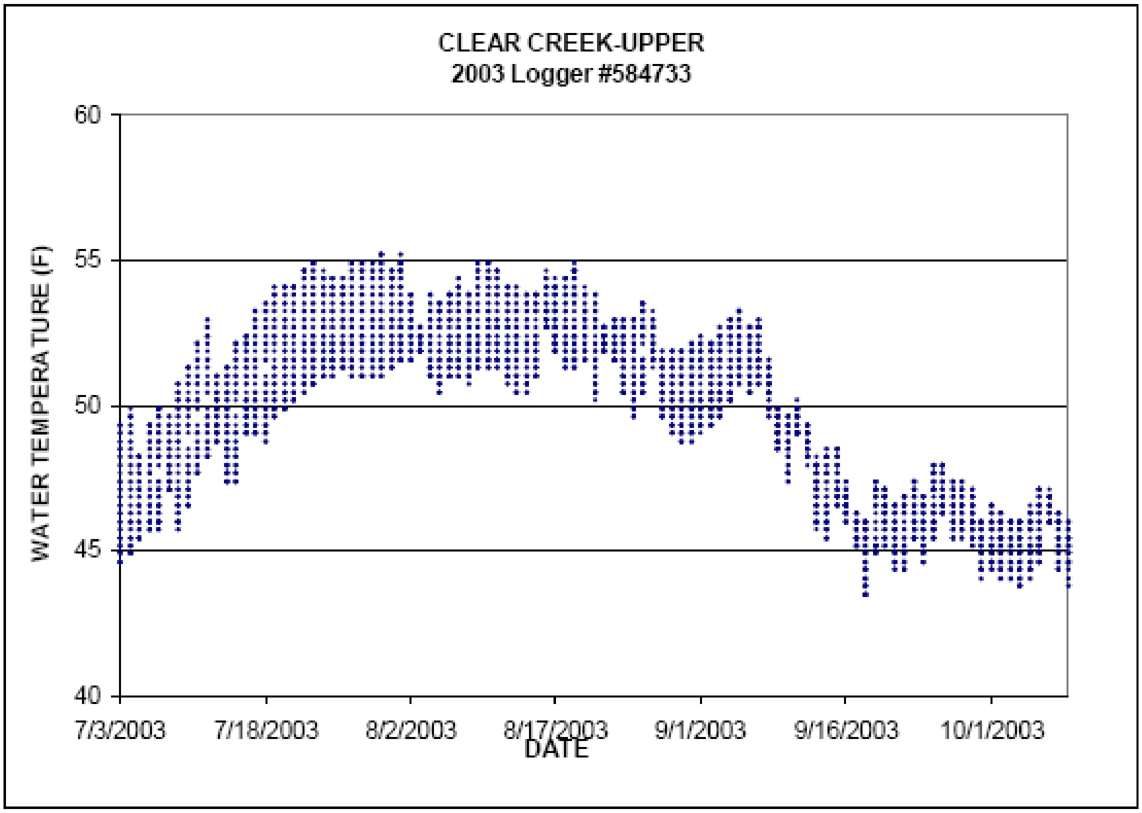
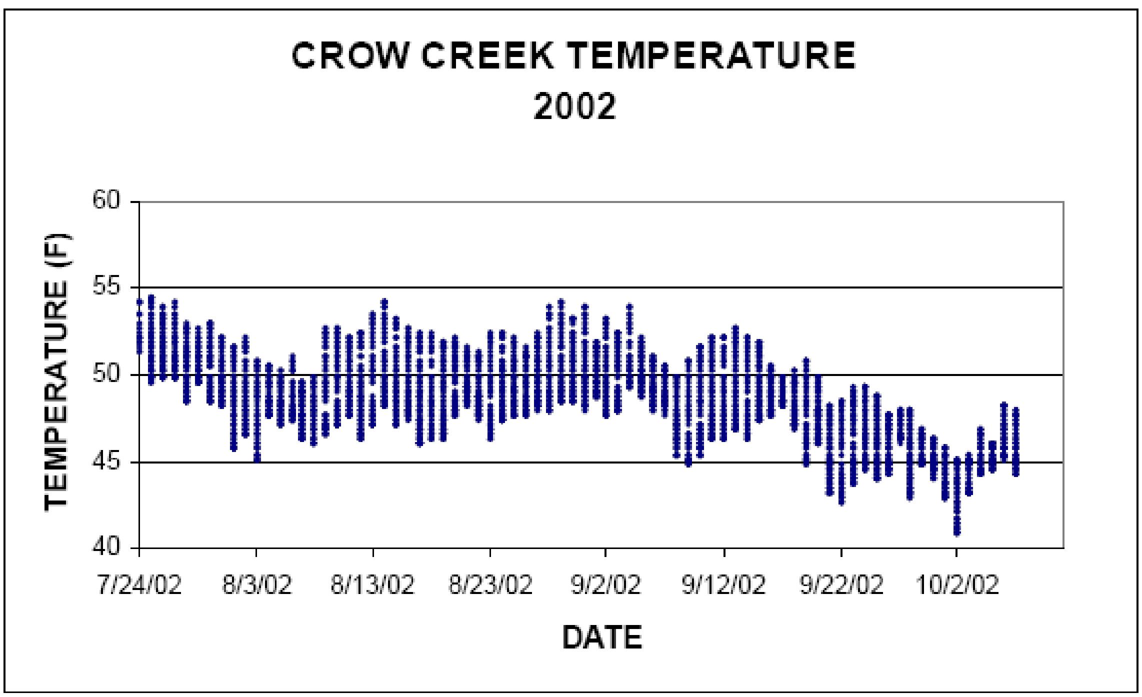


Figure I-5. Range of Temperatures Recorded in a 24 Hour Period from July through October in Prospect Creek Watershed, 2002-2003

Top two charts present data from Clear Creek near the mouth.
Bottom left chart presents data from Clear Creek above forest road 153 in 2002.
Bottom right chart presents data from the middle Clear Creek site in 2003.
All sites are in Clear HUC 6.


CLEAR CREEK-UPPER
2003 Logger #584733
WATER TEMPERATURE (F)
60
55
50
45
40
7/3/2003
7/18/2003
8/2/2003
8/17/2003
9/1/2003
9/16/2003
10/1/2003
DATE


CROW CREEK TEMPERATURE
2002
TEMPERATURE (F)
60
55
50
45
40
7/24/02
8/3/02
8/13/02
8/23/02
9/2/02
9/12/02
9/22/02
10/2/02
DATE

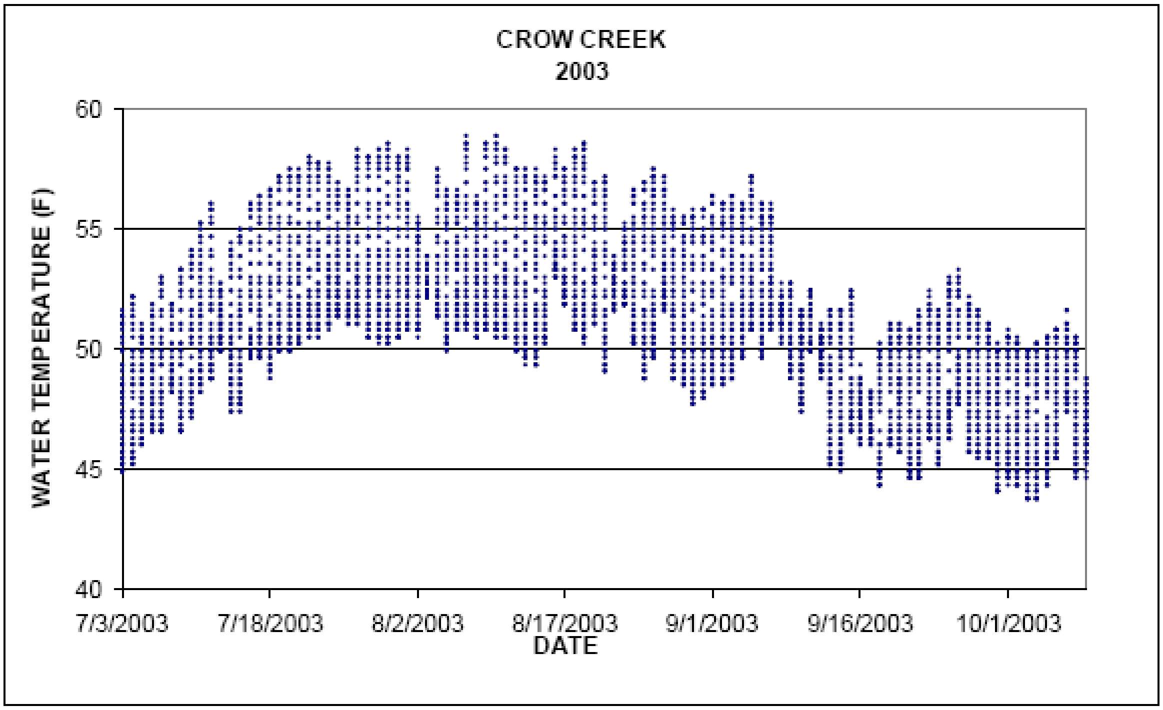
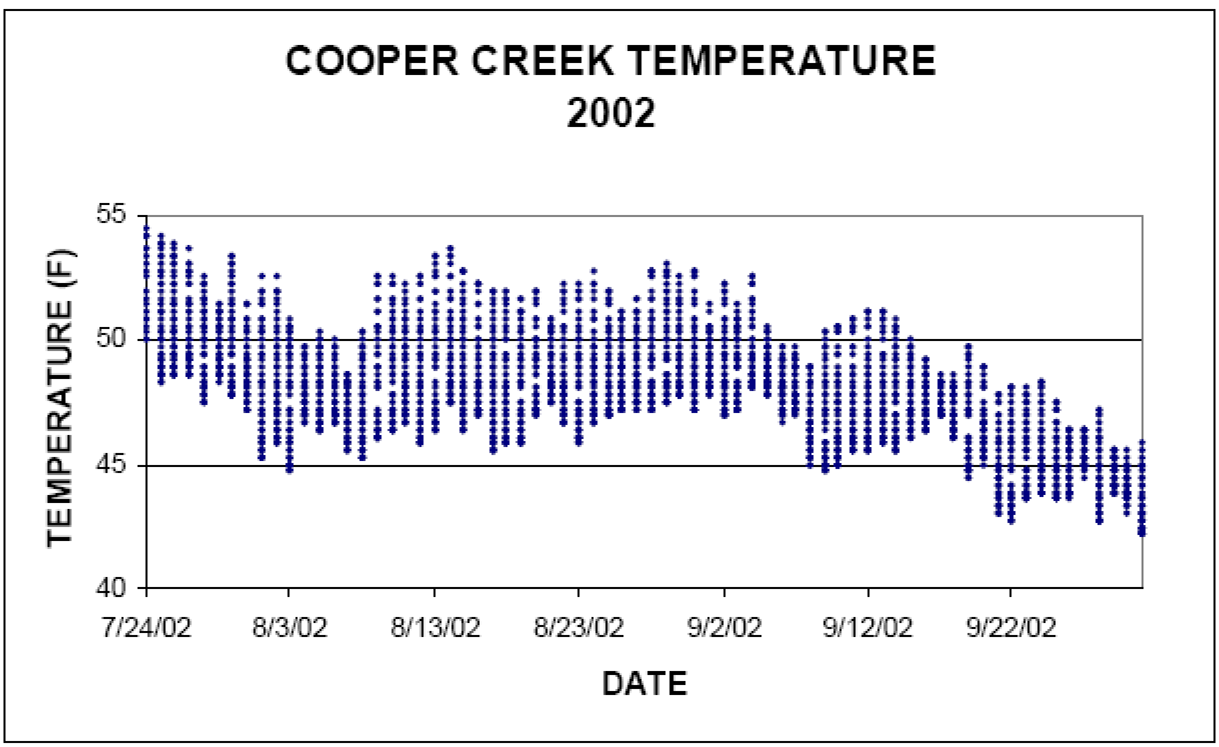
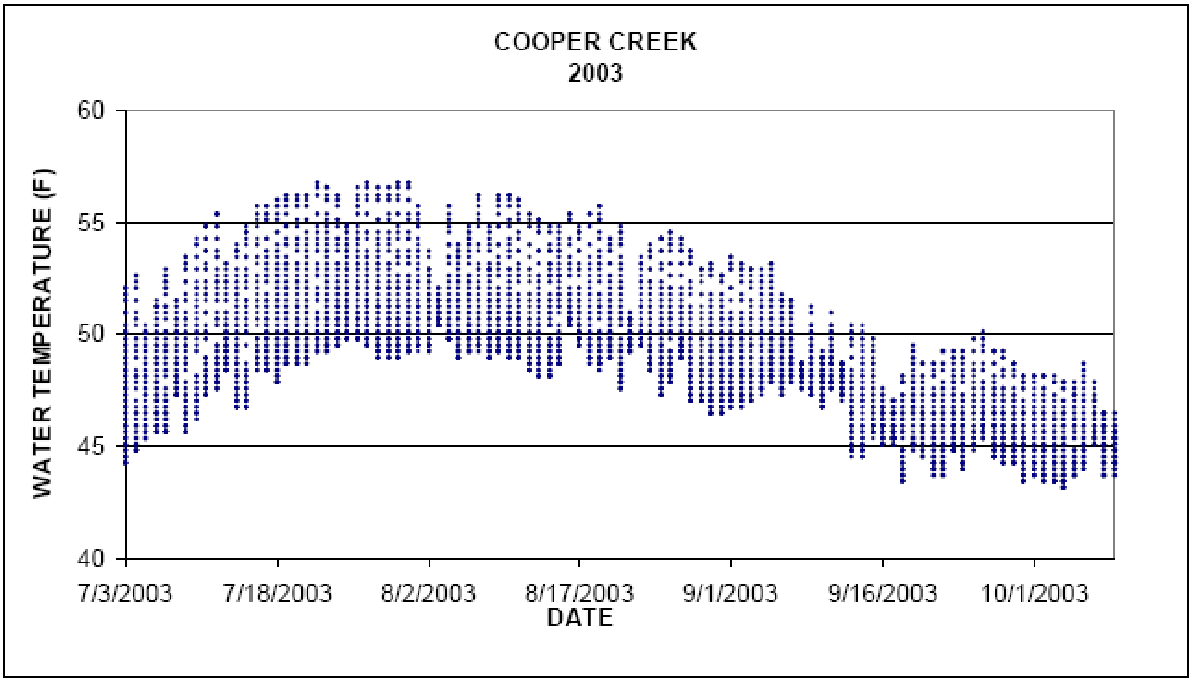
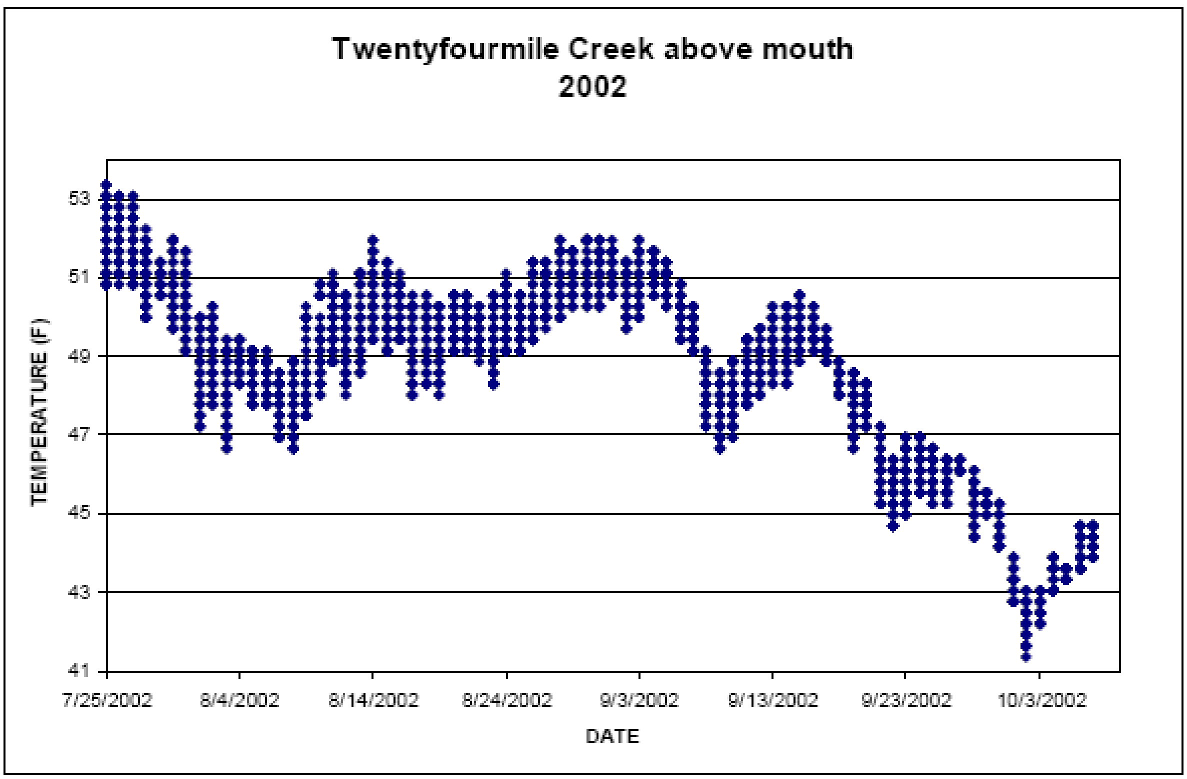


Figure I-6. Range of Temperatures Recorded in a 24 Hour Period from July through October in Prospect Creek Watershed, 2002-2003
Top left chart presents data from Upper Clear Creek in Clear HUC 6.
Bottom two charts present data from upstream of the mouth of Crow Creek in Crow HUC 6.




COOPER CREEK
2003
WATER TEMPERATURE (F)
60
55
50
45
40
7/3/2003
7/18/2003
8/2/2003
8/17/2003
9/1/2003
9/16/2003
10/1/2003
DATE


Twentyfourmile Creek above mouth
2002
TEMPERATURE (F)
53
51
49
47
45
43
41
7/25/2002
8/4/2002
8/14/2002
8/24/2002
9/3/2002
9/13/2002
9/23/2002
10/3/2002
DATE

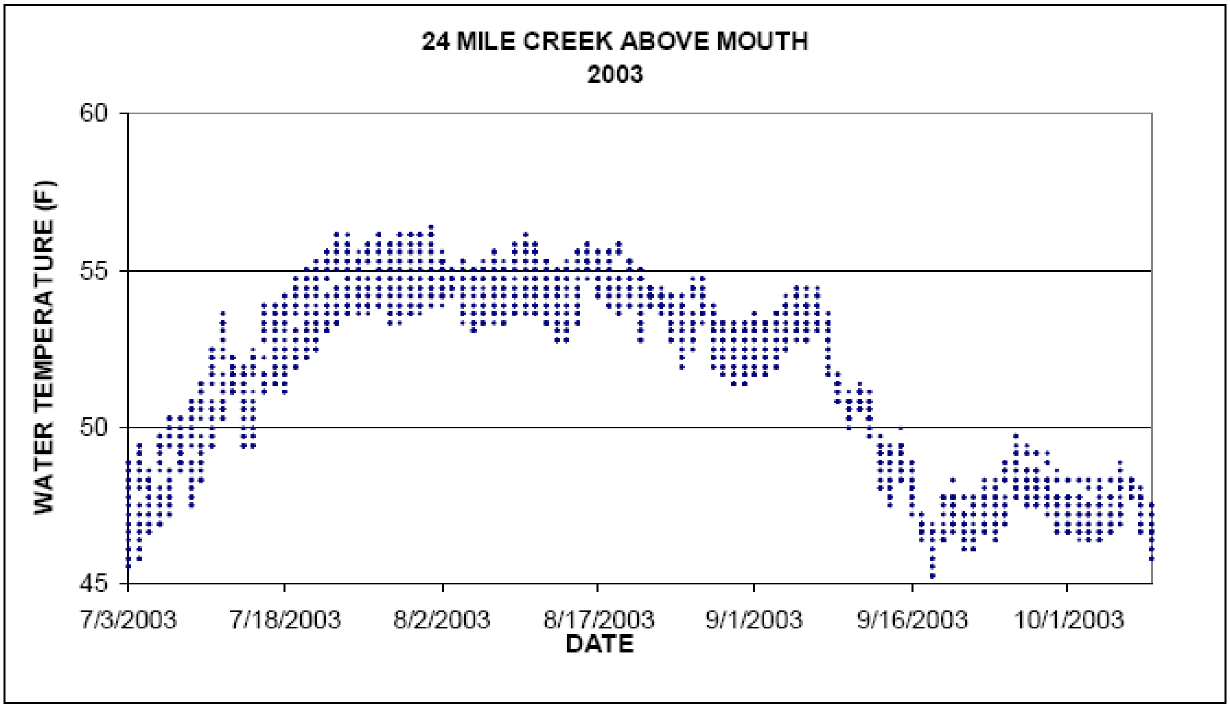


Figure I-7. Range of Temperatures Recorded in a 24 Hour Period from July through October in Prospect Creek Watershed, 2002-2003
Top two charts present data from upstream of the mouth of Cooper Creek in Cooper HUC 6.
Bottom two charts present data from upstream of the mouth of Twentyfourmile Creek in Upper Prospect HUC 6.

Table I-2. Summary of DEQ Temperature Data in Prospect Creek Watershed

Serial Number	Location	Start Date	Stop Date	Maximum of 7-Day Ave. Temps. (°F)	Max. 7-Day Ave. Date	Days >54° F*	Days >59° F*
530223	Prospect above Crow Cr	7/25/02	10/7/02	48.7	8/12/02	0	0
530224	Prospect above Coyote Cr	7/25/02	10/7/02	55.7	8/14/02	28	0
530226	Prospect above Clear Cr	7/25/02	10/7/02	60.5	8/12/02	61	25
476524	Knox Cr at the mouth	7/26/02	10/6/02	53.9	7/29/02	5	0
530221	Cooper Creek 1.5 mi up Rd 7623	7/25/02	10/7/02	52.9	7/28/02	1	0
530222	Crow Cr above the mouth	7/25/02	10/7/02	53.3	7/28/02	4	0
530228	Clear Cr above Rd 153	7/25/02	10/6/02	51.9	7/28/02	0	0
230227	Clear Cr at the mouth	7/25/02	10/7/02	60.8	8/12/02	58	25
530229	E F Dry Creek above Knox Cr	7/26/02	10/7/02	54.5	7/29/02	6	0
530230	Dry Creek near the mouth	7/26/02	10/7/02	47.2	8/12/02	0	0
530225	Wilkes Cr above Trail Head	7/25/02	10/7/02	57.0	7/28/02	27	1
476522	24 Mile Cr Above Mouth	7/3/03	10/9/03	56.1	07/29/03	44	0
476524	Knox Creek At Mouth	7/3/03	10/9/03	59.4	07/29/03	62	12
584731	E Fork of Dry Creek	7/3/03	10/9/03	59.7	07/25/03	58	15
584732	Dry Creek At Mouth	7/3/03	9/24/03	48.5	08/10/03	0	0
584733	Clear Creek Upper	7/3/03	10/9/03	54.9	07/29/03	24	0
584786	Clear Creek-Middle	7/3/03	10/9/03	49.0	08/27/03	0	0
584787	Clear Creek At Mouth	7/3/03	10/9/03	67.8	08/11/03	93	66
584788	Prospect Above 24Mile Creek	7/3/03	10/9/03	58.4	07/29/03	51	1
584789	Cooper Creek	7/3/03	10/9/03	56.5	07/29/03	44	0
584806	Crow Creek	7/3/03	10/9/03	58.0	07/29/03	57	0

Table I-2. Summary of DEQ Temperature Data in Prospect Creek Watershed

Serial Number	Location	Start Date	Stop Date	Maximum of 7-Day Ave. Temps. (°F)	Max. 7-Day Ave. Date	Days >54° F*	Days >59° F*
584807	Prospect Above Crow	7/3/03	9/19/03	49.1	07/19/03	0	0
584846	Prospect Above Coyote	7/3/03	10/9/03	57.7	07/20/03	62	0
584847	Wilkes Creek Above T.H.	7/3/03	10/9/03	62.5	07/25/03	68	39
58489	Prospect Above Clear Creek	7/3/03	10/9/03	65.1	07/20/03	94	62

* Absolute total number of days where temperature exceeded the threshold.

Table I-3. Comparison of Water Temperatures and Canopy Density Analysis in Main Stem Prospect Creek

Temp. Serial Number	Temp. Sample Location	Temp. Date	Reach	Nearby Cross Section (2003)	Width-to-Depth (2003)	Canopy Density Analysis Site+	Maximum of 7-Day Temp. Averages (°F)	Days >54° F*	Days >59° F*	Average % Riparian Canopy Density+	Average % Riparian Canopy Density$
530226	Prospect above Clear Cr	2002	2	RDG XS 3	36.2	3 – 5	60.5	61	25	32	8
58489	Prospect Above Clear Creek	2003	2	RDG XS 3	36.2	3 – 5	65.1	94	62	32	8
530224	Prospect above Coyote Cr	2002	3	RDG XS 1	30.4	5 – 7	55.7	28	0	50	--
584846	Prospect Above Coyote	2003	3	RDG XS 1	30.4	5 – 7	57.7	62	0	50	--
530223	Prospect above Crow Cr	2002	3	RDG XS 2	319.1	27– 29	48.7	0	0	58	--
584807	Prospect Above Crow	2003	3	RDG XS 2	319.1	27– 29	49.1	0	0	58	--
584788	Prospect Above 24Mile Creek	2003	5	LNF	26.6	20-22	58.4	51	1	59	--

* Absolute total number of days where temperature exceeded the threshold.

+ As measured and described in RDG 2004.

$ DEQ field verification 2005 using densiometer and EMAP methods.

Discussion

Several factors influence stream temperatures including land management, canopy density, groundwater discharge, precipitation, and seasonality. Historic and present impacts in the Prospect Creek watershed affect stream temperature in Prospect Creek. Wildfires, flooding, road construction, and bank stabilization efforts have contributed to increased channel width throughout mainstem Prospect Creek in reaches 2 through 4. Riparian clearing, riparian grazing, and floodplain development have negatively impacted stream shading by decreasing vegetation density and species diversity. Decreases in canopy density and increases in overall channel width equate to less stream surface shade and higher stream temperatures, especially in the lower watershed.
In **Table I-3**, an increase in canopy density generally correlates to a decrease in water temperatures

References

Katzman, L. 2003. Prospect Creek Westslope Cutthroat Trout and Bull Trout Life History Study – Final Report – 2000. Fish Passage/Native Salmonid Restoration Program, Appendix C. Noxon, Montana: Montana Fish, Wildlife and Parks and Avista Corporation.

Lindgren, H., 2005 Personal communication. Email from H. Lindgren to A. Beussink, RDG, regarding canopy density measurement methods and results. September 19, 2005.

Lazorchak, J.M., B.H. Hill, D.K. Averill, D.V. Peck, D.J. Klemm editors. 2000. Environmental Monitoring and Assessment Program – Surface Waters: Field Operations and Methods for Measuring the Ecological Condition of Non-Wadeable Rivers and Atreams. Cincinnati OH: U. S. Environmental Protection Agency. Report nr EPA/620/R-00/007.

River Design Group. 2004. Final Prospect Creek Watershed Assessment and Water Quality Restoration Plan. Whitefish, Montana: River Design Group.